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THE INFLUENCE OF INBREEDING UPON THE WEIGHT AND SIZE OF DAIRY CATTLE[1]

S. MARGOLIN AND J. W. BARTLETT
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IN RECENT years, much work has been conducted with laboratory animals in an attempt to determine the effect of inbreeding upon growth and to evaluate this method of breeding as a possible instrument for improving livestock. Although close inbreeding was extensively practiced by the pioneer breeders—Bakewell, the Collings, Bates, Cruickshank, etc., this system of mating was abandoned by their successors. The study of the effect of inbreeding on laboratory animals revived the interest in its application to cattle. King's (1918) thorough investigations with the Norway albino rat clearly demonstrated that mammals could be intensively inbred without loss of vigor or reduction in size. She practiced rigid selection from the seventh generation until the conclusion of her experiments at the twenty-eight generation. By this process it was possible to keep the animals to a high standard for body size and to make the strain apparently immune to the injurious effects that would probably have followed from random matings. Even after the 28 generations of continued brother-sister matings the inbred animals did not deteriorate in any way, and these animals continued to be superior in body size to control stock animals reared under similar conditions. (Inbred females as a rule were slightly heavier at any given age than the females of the control series.)

The investigations in inbreeding guinea pigs carried on from 1906 to 1937 by the United States Department of Agriculture (Wright, 1922; Eaton, 1940) showed less promise for the use of close-breeding as a practical method for improving livestock. Marked reduction in size and definite loss of vigor were observed during the first few generations but subsequent matings showed no further deterioration. However, these workers did not use a system of rigid selection. The value of inbreeding derives from the Mendelian mechanism whereby homozygosity is established for desirable as well as undesirable genes by such close-matings. In rigid selection animals apparently homozygous for unwanted genes are not permitted to reproduce, whereas those individuals demonstrating an apparent homozygosity for desirable genes are utilized in further matings.

Of late, inbreeding has been applied to the bovine on an experimental basis. Woodward and Graves (1933) inbred cattle to determine whether a good dairy herd could be bred from an ordinary one by the use of only one

[1] Journal Series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Dairy Husbandry.

good bull. Their analysis indicated that intense inbreeding resulted in markedly reduced birth weight and apparently in decrease rate of growth of calves. These workers also suggested that inbreeding resulted in reduced mature weight.

Kolesnik (1940) presented evidence demonstrating lower birth weights in randomly inbred calf populations. This result was attributed to the genetic basis of the inbred groups and was traceable to the sires.

TABLE 1. COMPARISON OF BODY WEIGHTS OF INBRED AND OUTBRED DAIRY CATTLE FROM BIRTH TO MATURITY

Age (Months)	Outbred controls		Inbred								Ragsdale standard
	No. Anim.	Weight	No. Anim.	C. I.** .05–.09	No. Anim.	C. I. .10–.14	No. Anim.	C. I. .15–.19	No. Anim.	C. I. .20 & over	
		lbs.		lbs.		lbs.		lbs.		lbs.	lbs.
Birth	12	96	9	95	8	99	3	113*	3	93	90
3	12	213	9	215	8	208	3	232	3	214	193
6	12	375	9	365	9	369	3	355	3	351	355
9	12	486	9	476	9	481	3	432*	3	489	509
12	12	595	9	598	9	608	3	527*	3	582	632
18	12	780	9	710*	9	793	3	728	3	734	845
24	12	940	9	926	9	946	3	853*	4	895	1069
30	12	1097	9	1054	8	1086	3	1013	4	991*	1120
36	12	1146	9	1130	9	1163	3	1083	4	1010*	1165
42	12	1241	9	1223	9	1257	3	1142*	4	1077*	1202
48	12	1256	9	1218	9	1261	3	1119*	4	1088*	1232
54	12	1318	9	1266	9	1316	3	1243	2	1190	1271
60	12	1308	8	1306	7	1348	3	1303	2	1154	1330
66	8	1332	7	1326	6	1328	3	1284	2	1155	1312
72	8	1401	5	1284	5	1431	3	1341	2	1330	1317
78	4	1372	5	1337	5	1312	2	1436			1357
84	2	1501	5	1405	4	1369					1401
90			3	1373	3	1543					1358

* Differs significantly from control.
** Coefficient of inbreeding.

In a preliminary report, Bartlett, Reece and Mixner (1939) concluded that dairy cattle could be inbred successfully provided a rigid system of selection was followed. Growth of close-bred calves and heifers was not significantly different from that of outbred animals. A more complete study by Bartlett, Reece and Lepard (1942) also failed to discern any significant difference in growth rate between inbred and outbred heifers. Bartlett and Margolin (1944) observed that Holstein-Friesian cattle inbred to a coefficient of 0.20 were equal in frame size (height and chest circumference) to outbred controls.

Materials and Methods

The results reported in this paper were obtained from the records of a project on inbreeding and outbreeding Holstein-Friesian cattle at the New

Jersey Agricultural Experiment Station. This project was begun in 1930–31 with 45 outbred cows and four outbred sires. The foundation cows had been selected on the basis of normal size, good type and mature equivalent class C fat production of 480 pounds with the milk testing at least 3.6 percent butterfat. Three of the foundation bulls were proven sires with mature "B" indexes of 600 pounds of fat and 3.8 percent butterfat test or better. The unproven fourth sire was out of a dam with a 600 pound butter-

TABLE 2. COMPARISON OF WITHERS HEIGHT OF INBRED AND OUTBRED DAIRY CATTLE FROM BIRTH TO MATURITY

Age (Months)	Outbred controls		Inbred								Ragsdale standard
	No. Anim.	Height	No. Anim.	C. I.** .05–.09	No. Anim.	C. I. .10–.14	No. Anim.	C. I. .15–.19	No. Anim.	C. I. .20 & Over	
		cm.		cm.		cm.		cm.		cm.	cm.
Birth	12	77.9	9	78.3	8	78.6	3	80.0	3	77.7	73.9
3	12	91.9	9	92.9	8	91.6	3	93.3	3	91.7	87.1
6	12	104.5	9	104.3	9	103.9	3	104.0	3	104.3	100.8
9	12	112.8	9	111.8	9	111.6	3	110.3	3	112.3	110.5
12	12	118.3	9	118.3	9	119.7	3	116.0	3	117.0	116.8
18	12	125.3	9	124.4	9	127.0	3	123.3	3	124.0	125.2
24	12	130.9	9	128.9	9	132.1	3	128.0	4	127.3	131.3
30	12	134.2	9	133.1	8	134.9	3	131.3*	4	130.0	133.4
36	12	135.8	9	134.8	9	135.8	3	134.7	4	132.0	134.6
42	12	136.3	9	136.4	9	138.7	3	136.3	4	133.0	135.1
48	12	138.0	9	138.3	9	139.3	3	136.3	4	134.7	135.4
54	12	137.8	9	137.8	9	139.8	3	137.7	2	133.0	136.1
60	12	138.0	8	137.4	7	140.6	3	137.7	2	133.5	136.1
66	8	138.4	7	137.7	6	140.2	3	138.3	2	134.5	136.4
72	8	138.3	5	138.8	5	142.0	3	138.3	2	134.0	136.4
78	4	140.0	5	138.0	5	142.4	2	139.0			137.2
84	2	141.0	5	137.4	4	141.0					136.4
90			3	141.7	3	141.7					136.4

* Differs significantly from control.
** Coefficient of inbreeding.

fat record and testing 4.0 percent butterfat (see N. J. Agr. Exp. Sta. Bull. 667, 1939).

Progeny of the foundation animals were mated as follows: (a) sire-daughter matings; (b) brother-sister matings; (c) matings with less than 50 percent of the same blood; and (d) outbreeding. The last system of mating has furnished adequate controls for the inbreeding investigations. Of the inbred and outbred animals now in the herd, a great majority are the result of mating descendants of one of the foundation sires, Ormsby Sensation 45th 442551. Only descendants of this sire were included in this investigation. In the comparisons presented below, outbreds that are descendants of Ormsby Sensation 45th are utilized as controls for inbred descendants of this same sire. Extensive use of the other foundation sires or their progeny was dis-

continued during the first few years of the experiment. This was prior to June, 1935 when all females in the herd were weighed and measured for height at the withers and for chest circumference. Measurements and weights were taken monthly until the animals were 10 months old. Subsequent measurements and weights were taken at intervals of 3 months. Only those

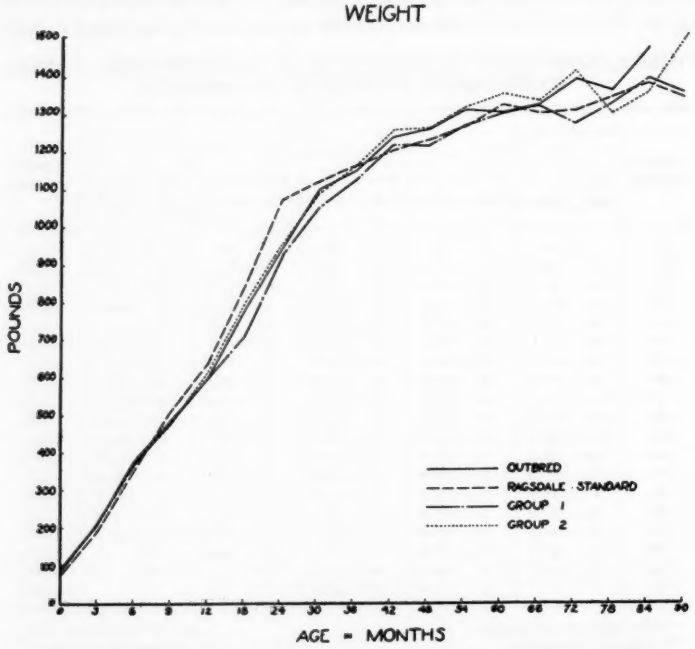

Figure 1. Comparison of body weights of inbred groups with outbred controls. Inbreeding coefficients for group 1 ranged from 0.05 to 0.09; for group 2, 0.10–0.14.

animals with continuous records to 48 months of age, or longer, have been used. This was done in order to approximate a consistent population from birth to maturity.

Wright's (1922*a*) coefficient of inbreeding was employed in estimating the degree of inbreeding of the animals. In analyzing the growth records, "Students" *t*-test (Snedecor, 1938) was used to determine whether the difference between certain means was significant. Inasmuch as normal size was one criterion used in the selection of the foundation herd, it was of interest to determine whether the growth and the rate of growth made by the ani-

mals were normal. For this determination, Ragsdale's (1934) growth standards were employed.

Rigid selection for size, type, production and vigor has been consistently practiced for all outbred and inbred matings. The records show that the incidence of culling for the inbred animals of the Ormsby Sensation 45th blood-

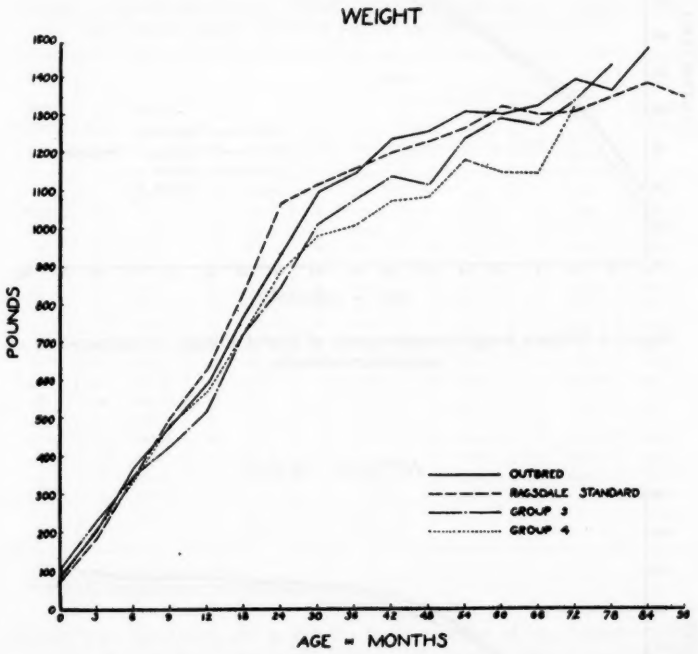

Figure 2. Comparison of body weights of highly inbred groups with outbred controls. Group 3 inbreeding coefficients varied from 0.15 to 0.20. Animals with an inbreeding coefficient of 0.20 or greater were placed in group 4.

line has not differed in the selection process from that of the outbreds of this same blood line at any stage of their development.

Results

Body Weight

The recorded weights of all females from birth through maturity are summarized in table 1 (see also figures 1 & 2). The Ragsdale "standard weight" for the respective ages is also listed.

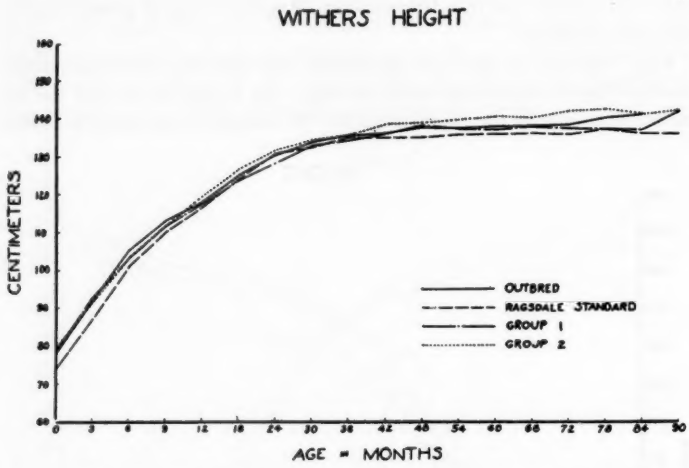

Figure 3. Withers height measurements of inbred animals as compared to values for outbreds.

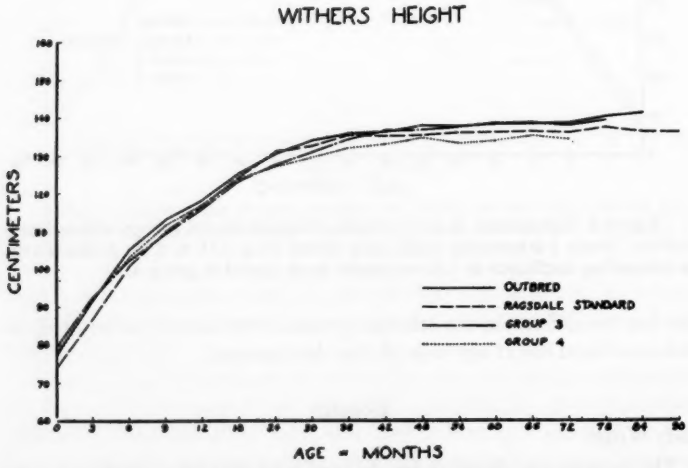

Figure 4. Withers height measurements of highly inbred animals as compared to values for outbreds.

Animals inbred up to an inbreeding coefficient of 0.14 were equal in weight to outbred controls at all stages of development, with the exception of the 18 month old females inbred 5 to 9 percent which were significantly lighter in body weight (approximately 70 pounds). The group inbred 15 to 19 percent was heavier in body weight than the controls at birth; this dif-

TABLE 3. COMPARISON OF CHEST CIRCUMFERENCE OF INBRED AND OUTBRED DAIRY CATTLE FROM BIRTH TO MATURITY

Age (Months)	No. Anim.	Outbred control	Inbred								Ragsdale standard
			No. Anim.	C. I.** .05–.09	No. Anim.	C. I. .10–.14	No. Anim.	C. I. .15–.19	No. Anim.	C. I. .20 & Over	
		cm.		cm.		cm.		cm.		cm.	cm.
Birth	12	81.0	9	79.6	8	79.9	3	83.3	3	76.7	78.2
3	12	105.5	9	104.0	8	103.4	3	107.3	3	105.3	94.0
6	12	126.2	9	123.7	9	125.1	3	123.0	3	124.3	123.7
9	12	137.6	9	137.9	9	138.9	3	135.3	3	137.7	138.7
12	12	152.2	9	151.4	9	152.4	3	145.7	3	146.0	149.6
18	12	166.3	9	162.2	9	167.3	3	160.7	3	162.0	164.9
24	12	177.2	9	173.1*	9	178.0	3	172.7	4	171.3	181.1
30	12	185.8	9	180.5	8	185.8	3	183.0	4	177.0	184.2
36	12	189.3	9	187.4	9	189.8	3	187.0	4	179.0*	187.5
42	12	192.6	9	192.6	9	195.2	3	189.0	4	184.8*	191.3
48	12	194.9	9	194.3	9	195.3	3	191.0	4	185.5*	191.0
54	12	198.8	9	195.2	9	199.9	3	192.0*	2	187.5	195.3
60	12	199.0	8	200.3	7	201.9	3	199.3	2	184.0	193.8
66	8	202.5	7	201.0	6	201.3	3	198.7	2	187.5	194.8
72	8	202.3	5	197.4	5	203.8	3	198.7	2	197.0	193.8
78	4	206.8	5	204.6	5	201.0	2	208.0			198.9
84	2	206.0	5	204.4	5	201.5					194.3
90			3	206.6	3	215.0					200.7

* Differs significantly from controls.
** Coefficient of inbreeding.

ference was significant. At 9 months to 48 months of age, however, this group tended to be significantly lighter than the outbred animals. Beyond 54 months of age these same animals were equal to the controls and the Ragsdale standard. The outbred controls and the groups inbred up to 14 percent were equal to the Ragsdale standard to 12 months. These females, however, fell significantly below the weight standard from 18 to 30 months of age. After 36 months these animals were equal to or significantly heavier in body weight than the Ragsdale standard.

The group inbred to a coefficient of 0.20 or greater was equal in weight to the controls from birth to 24 months. From 36 to 48 months these animals were significantly lighter than the outbred females (approximately 100 pounds). Data for only two animals beyond 48 months of age in this group showed a continued lighter mean body weight. These values, however,

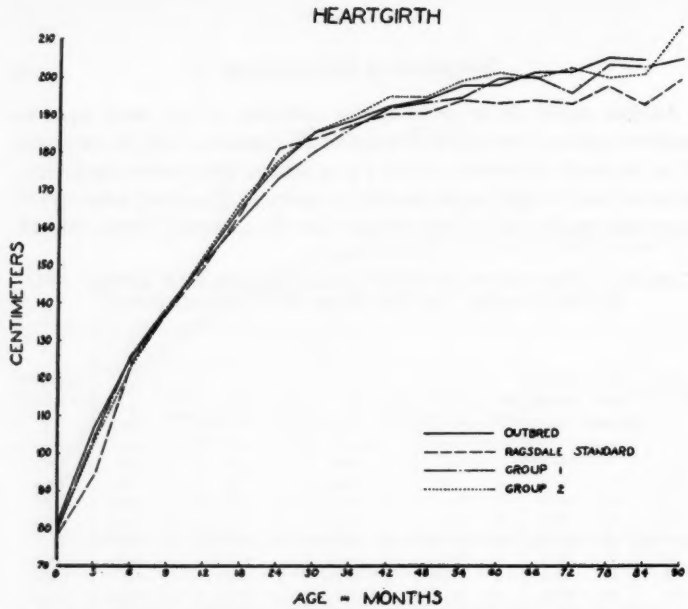

Figure 5. Heartgirth measurements of inbred cows as compared to outbred controls.

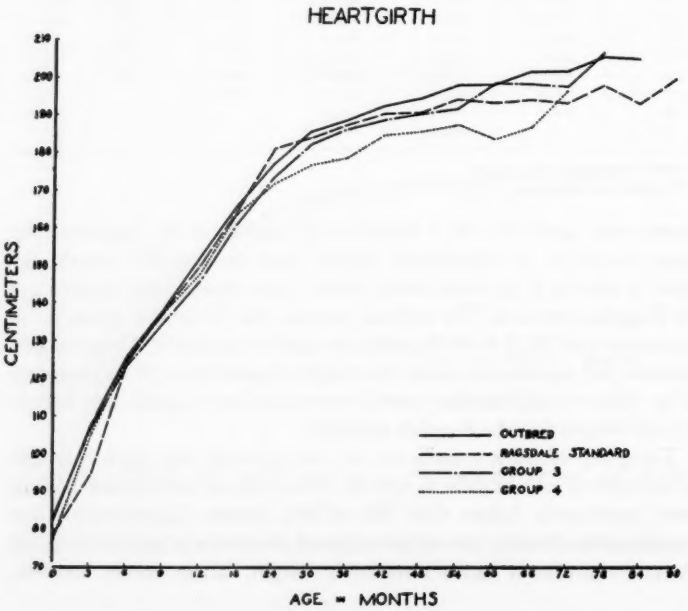

Figure 6. Heartgirth values measurements of highly inbred cows as compared to outbred controls.

were not significant statistically. At 72 months of age, the mean weight for these two individuals was equal to the Ragsdale standard.

The mature weight (6 years of age) of *all* groups was equal to or heavier than the Ragsdale standard.

Withers

The withers heights from birth to maturity for all inbred animals did not differ significantly from controls. Exclusive of the most highly inbred group, the inbred animals as well as the outbred controls were higher at the withers than the Ragsdale standard beyond 36 months of age (see table 2; figures 3 and 4).

Heartgirth

The chest measurements for all inbred groups did not vary significantly from controls at birth to 24 months of age (see table 3; figure 5 and 6). At 24 months of age the inbred group .05–.09 was significantly smaller in heartgirth measure, but recovered at 30 months, and remained equal to controls thereafter. The inbred group .15–.20 did not differ significantly from controls until 54 months of age when a decrease in chest circumference was observed. This, however, was overcome at 60 months, and the group then continued at the control group level. The most highly inbred group (inbreeding coefficient of .20 or over) were smaller in heartgirth from 30 to 72 months, significantly so from 36 to 48 months of age, when compared to controls.

The heartgirth measurements from birth to maturity of both outbred and inbred groups were equal to or better than the Ragsdale standard with the exception of development at 24 months of age. At this stage all groups were below the standard, and the most highly inbred group remained lower than the Ragsdale values until 72 months of age.

Discussion

The results reported are a confirmation and an extension of the earlier reports of the New Jersey Station which have established that inbreeding can be applied practically to the breeding of dairy cattle, provided superior foundation animals are used and rigid selection is employed.

The progeny of the Ormsby Sensation 45th family inbred to a coefficient of inbreeding of 0.20 were just as heavy, generally, as outbred animals of this same blood line, whereas those inbred more intensively were lighter at maturity (72 months).

These observations of growth in cattle are in agreement with the earlier work of King (1918) who clearly demonstrated that mammals could be inbred successfully provided exacting selection was practiced.

Generally, no significant difference in height at withers was observed be-

tween inbred animals and controls. These data, in addition, suggest that height at withers is not a reliable measure of growth beyond 42 months of age as the increments of change beyond this age are not significant, and Holstein-Friesian females are not classed as mature until 84 months by the Holstein-Friesian Association of America. Heartgirth is seemingly a more reliable measure of growth than withers height, and a more economic practice than body weight.

The smaller heartgirth, withers height, and body weight sharply apparent at first calving (approximately 28 months) for the most highly inbred females, after a normal development from birth, suggest some possible relationship between gestation or parturition, and the failure of these animals to follow a normal growth development to maturity.

Conclusions

This paper further confirms earlier work demonstrating that Holstein-Friesian dairy cattle can be inbred without necessarily causing a decrease in body weight or size at any stage, from birth to maturity, as compared to outbred controls of the same blood line, provided the Wright coefficient of inbreeding does not exceed 0.20. Females inbred to a coefficient greater than 0.20 develop normally to approximately first calving age, but show markedly abnormal development thereafter. However the animals in this group with growth records complete to 72 months of age do not vary significantly in mean weight, height and heartgirth from the Ragsdale standard, although they are still considerably smaller than the outbred controls.

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A STUDY OF THE GESTATION PERIODS OF FIVE BREEDS OF CATTLE[1]

E. A. Livesay and Ural G. Bee
West Virginia University

FOR a long period cattle breeders have considered the average gestation period of all breeds of cattle to be in the neighborhood of 283 days. Lush (1937) made a study of 27,810 gestations and found the average to be 282.1 days, which is close to the generally accepted average. Rife, *et al.* (1943) report a marked difference in the gestation periods of Hereford and Aberdeen-Angus cows maintained in the Ohio Experiment Station herds. The gestation periods of the same cows when cross-bred were approximately half way between. The Hereford cows when mated to a Hereford bull had an average gestation period of 289.0 days; the Aberdeen-Angus cows when mated to Aberdeen-Angus bulls had an average of 272.8 days; and when cross-breeding was practiced in both the Hereford and Aberdeen-Angus cows had an average of 281.4 days.

The West Virginia workers assumed that such variations were indications that the gestation period varied in accordance with earliness of maturity among breeds and is a heritable variation. Therefore, a study was made of the breeding records of the college herds at West Virginia University. If a difference exists in the gestation period, based on early and late maturity, it was felt that breeds such as the Jersey and Holstein Friesian would give the results to prove or disprove such an assumption.

The data in table 1 were summarized from the breeding records of the Animal Husbandry and Dairy Husbandry Departments. The records extended over a period of fifteen years. Only cases with definite breeding and birth records are included.

TABLE 1. GESTATION PERIODS OF TWO BREEDS OF BEEF CATTLE AND THREE BREEDS OF DAIRY CATTLE

Breed	Both sexes		Males		Females	
	No.	Ave. No. days	No.	Ave. No. days	No.	Ave. No. days
Aberdeen-Angus	173	282.5	79	282.7	94	282.2
Hereford	174	285.2	90	285.0	84	285.2
Jersey	265	277.9	141	278.6	124	277.2
Ayrshire	580	277.8	283	278.1	297	277.5
Holstein	415	278.3	213	278.7	202	277.7

[1] Approved by the Director, West Virginia Agricultural Experiment Station, Morgantown, W. Va., as Scientific per No. 332.

The records in table 1 show an average gestation period of 282.5 days for the Aberdeen-Angus and 285.2 for the Hereford breed, the period being longer by 2.7 days for the Hereford breed. This difference is highly significant.

The records in table 1 show an average gestation period of 277.9 days for the Jersey, 277.8 days for the Ayrshire, and 278.3 for the Holstein Friesian breed. The average days for the gestation period of each of these three dairy breeds do not vary significantly and hence any assumption that an early maturing breed, such as the Jersey, might have a shorter gestation period has no foundation.

The most interesting thing about the gestation period, as revealed by these breeding records, is that it is 5.8 days shorter in the dairy breeds than in the beef breeds. This figure represents the difference between the average of the gestation period of the two beef breeds and the average period of the three dairy breeds. An analysis of variance showed that the difference between the means of the gestation periods of the beef and dairy breeds was highly significant.

Table 1 also shows the number of male and female calves and the average of their respective gestation periods. These divisions are given for information, which may interest those who still hold that male calves have a slightly longer gestation period than females, or vice versa.

Conclusions

The breeding records of the Aberdeen Angus and Hereford herds at West Virginia University do not reveal the wide difference (16.2 days) between the gestation period of these two beef breeds as found at the Ohio Experiment Station. The difference in these breeds was 2.7 days. This difference, however, was highly significant.

The breeding records of the Jersey, Ayrshire and Holstein Friesian herds at this institution do not show that an early maturing breed like the Jersey has a shorter gestation period than slower maturing breeds.

The data show a significantly shorter gestation period for the dairy breeds as compared with the beef breeds in the herds of this institution, the difference being 5.8 days.

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THE EFFECT OF SEX ON WEANING WEIGHT OF RANGE CALVES[1]

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IT IS generally recognized that males of most species of domestic animals grow more rapidly and reach a greater mature weight than femlaes. Published data showing the difference in growth rate of the sexes in beef cattle, however, are relatively scarce.

Morrison (1936) has summarized data from a number of sources on the normal growth rates of bull and heifer calves of the dairy breeds. These data showed that bulls grew faster in both weight and height than heifers in all four breeds. Reports concerning the sex differences in beef cattle are not in complete agreement. Lush, *et al.* (1930) observed the growth of cattle under range conditions for a number of years and stated that steers consistently grew at a slightly faster rate than heifers. Knapp and Black (1941) reported that sex had a significant influence on rate of gain of beef calves during the suckling period. Their study included bull, steer, and heifer calves. The data were not given in detail but it was stated that the heaviest calves were bulls and were from cows giving the largest amount of milk. Knapp and Phillips (1942) reported that there was not a significant difference in weaning weight between sexes by the same sire. Johnson (1943) likewise concluded from data on thirty-eight calves that there was no difference in gains made by heifer and steer calves running with dams on summer range, and reported that gains made by yearlings on summer pasture were similar.

The weights of calves produced on the experimental range of the New Mexico Agricultural Experiment Station clearly indicate a difference between sexes. Due to the scarcity of published data and the fact that sex differences have an effect on evaluating the relative producing ability of beef animals, the information collected at this Station over a period of years is presented.

Source and Treatment of Data

The weaning weights of calves reported in this paper were obtained at the New Mexico Agricultural College experimental range, from 1936 through 1943. The calves were from high-grade Hereford cows and sired by Hereford bulls. The calves were dropped from March through May, a majority of them being born in April. Sexes were not separated and bull calves were castrated around the first of June. All calves were weaned at one time in

[1] Published with approval of the Director of the New Mexico Agricultural Experiment Station. Contribution No. 31.

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TABLE 1.—NUMBERS OF CALVES INCLUDED BY YEARS

Year	Number of calves	
	Steers	Heifers
1936	15	14
1937	46	38
1938	52	56
1939	58	66
1940	62	61
1941	54	76
1942	64	66
1943	68	67
Total	419	444

October or early November, depending upon feed supply and other factors. The calves were weighed on standard customs scales located at convenient places on the ranch within a few hours after the calves were brought from pasture.

Weaning age of the calves varied over a range of approximately 100 days, so the method of covariance was used to correct all weights to 205 days of age.

Since the reports of Knapp and Phillips (1942) and Comstock, Winters, and Cummings (1944) suggest that sex differences in the progeny of some males is greater than in others, it seemed desirable to test the sex×sire within year interaction for significance. For this purpose, only bulls with 10 or more calves per year were included. The data were classified by sex, year, and bull. Each cell was then filled in with the corrected mean and analysis of

TABLE 2.—MEAN WEANING AGES AND WEIGHTS OF CALVES BY YEARS AND SEX

Year	Age in days		Weight in pounds	
	Steers	Heifers	Steers	Heifers
1936	203	202	439	427
1937	207	204	489	451
1938	195	200	453	421
1939	212	218	452	437
1940	207	216	445	422
1941	204	207	452	413
1942	212	218	473	438
1943	192	199	356	343
Weighted average	204	209	442	416

variance performed in the usual manner. The variances used to test signfiicance of variance due to sex and to sex×sire within year interaction were "within sex" and "within sire, sex and year" errors of estimate respectively. The number of animals in subgroups was unequal and the error variances were corrected for disproportionate subclass numbers as described by Snedecor (1940).

TABLE 3.—CORRECTED WEANING WEIGHTS OF CALVES BY YEARS AND SEX*

Year	Corrected weight		Difference in favor of steers
	Steers	Heifers	
	Pounds	*Pounds*	*Pounds*
1936	441	431	10
1937	487	452	35
1938	465	426	39
1939	444	421	23
1940	443	409	34
1941	453	411	42
1942	465	422	43
1943	372	350	22
Weighted average	443	411	32

* The average regression of weight on age was 1.21 pounds per day. All weights corrected to 205 days of age.

Results and Discussion

During each year thus far recorded, the steer calves have outweighed the heifers at weaning time (table 2). The average difference in weight over the eight-year period was 26 pounds in favor of the steers. When the mean weights were corrected for differences in age (table 3), the average difference was 32 pounds in favor of the steers. These differences were highly significant (table 5).

It is an interesting fact that, except for the first two years when numbers of calves were small (table 1), the bull calves were dropped an average of five days later than heifers (table 2). This is possibly explained by bull calves being carried *in utero* longer than females.

The data are summarized also by bulls (table 4). The values shown were derived by averaging the corrected yearly mean weights for the different sexes. The difference in sex was in favor of the steer calves in every instance. The difference between sexes was greater for some bulls than for others, but these differences were not great enough to be statistically significant (table 5). These data do not show a significant tendency for the sex differences to be greater for some sires than for others and in this respect they differ from

TABLE 4.—CORRECTED WEANING WEIGHTS OF CALVES BY SIRES AND SEX*

Sire number	Number of calves	Corrected weight of calves		Difference in favor of steers
		Steers	Heifers	
		Pounds	*Pounds*	*Pounds*
1	29	429	420	9
2	122	463	434	29
3	47	450	412	38
4	128	476	439	37
5	127	452	421	31
6	48	436	418	18
7	70	466	429	37
8	66	436	416	20
9	41	415	405	10
10	42	427	389	38
11	38	426	372	54
12	20	411	401	10

* Bulls with less than 20 calves excluded.

the reports of Knapp and Phillips (1942) and Comstock, Winters, and Cummings (1944). However, the bulls used in this study, with two exceptions, were related and would not be expected to show as much variation as a group of unrelated sires.

The difference in weaning weight of steers and heifers encountered at this Station is large enough to necessitate correction for sex in evaluating the progeny of different animals if numbers of the two sexes are disproportionate. Where numbers of calves are small, the error introduced by not correcting may be appreciable.

Summary

The weaning weights of steer and heifer calves grown under range conditions have been observed for a period of eight years. The mean weights of the two sexes corrected for difference in weaning age were 443 pounds for 419

TABLE 5.—VARIANCE DUE TO SEX AND SEX×SIRE INTERACTION WITH VARIANCES APPROPRIATE FOR TESTING SIGNIFICANCE

Source of variance	D. F.	Mean square
Sex	1	19,879*
Within sex	775	419
Sex×sire within year	39	190
Calves within sire, sex, and year	683	172

* Significant at 1-percent level.

steers and 411 pounds for 444 heifers. Steers were heavier than heifers each year. The difference in favor of steer calves was highly significant.

The difference in weight of sexes was tabulated for the offspring of 12 bulls, 10 of which were related. Steers were heavier than heifers for all sires. The sex×sire within year interaction was small, indicating that sex differences did not vary significantly among sires.

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DIAGNOSIS OF POISONING OF BEEF CALVES BY LEAD PAINT[1]

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LEAD poisoning is sometimes encountered in calves and the symptoms may be confused with other conditions. Data are presented in which clinical symptoms and chemical analyses of glands from calves that had received known amounts of lead were similar to those observed in calves in the beef production herd.

Since 1933, considerable difficulty has been experienced in raising calves from beef cows and heifers in one of the University herds. The standard practice has been to feed the cows a ration of silage, cottonseed meal and oat straw in the winter and to offer the calves ground corn and legume hay as soon as they would eat it.

The calves have been uniformly normal at birth but in some cases, between four and eight weeks of age, they began to show marked clinical symptoms that in the majority of cases terminated in death. These symptoms were characterized by failure of calves to nurse, refusal of feed, muscular tremors, partial or complete blindness, staggering, convulsions and death. The failure to nurse seemed to be due to a paralysis of the throat muscles. Autopsy showed the calves to be in a good condition. Although some pathological conditions were observed, the most consistent finding was nephrosis or degenerative changes in the kidney. In some cases the degenerative changes were recent, while in others there was also some fibrosis.

Attempts were made to improve the nutritive quality of both the cow and calf ration without results.

Blood, urine and milk analyses showed no abnormalities sufficient to account for the clinical symptoms and autopsy findings. Red, white and differential cell counts and calcium and magnesium content of the blood were determined. Qualitative tests for protein, sugar and acetone bodies were made on the urine; solids, protein, fat, lactose and ash were determined in the milk. In some cases protein was found in the urine of the calves. The brain and spinal cord from some of these affected animals were examined bacteriologically and histologically without revealing evidence of infectious disease.

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[2] The assistance of Mr. E. D. Schall in the analyses of lead is gratefully acknowledged.
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TABLE 1. SYMPTOMS OF CALVES AND LEAD ANALYSIS OF THEIR LIVERS

Group	Animal	Age at death or slaughter	Clinical symptoms	Autopsy findings	Lead in dry liver
		days			*Mg. per Kg.*
Controls[a]	5 cows	Unknown	Not observed	Normal	0.01 (0.0–0.06)
	5 calves	Unknown	Not observed	Normal	0.93 (0.0–3.75)
1[b]—Young nursing calves	87 calf	39	None	Nephrosis	25.0
	76 calf	77	Convulsions	Nephrosis	99.6
	88 calf	49	Convulsions	Nephrosis	85.5
	100 calf	32	Blindness	Nephrosis	30.1
	97 calf	89	Convulsions	Nephrosis	18.4
	90 calf	147	Convulsions	Nephrosis	5.5
	12 calf	35	Convulsions	Nephrosis	106.8
	98 calf	51	Convulsions	Nephrosis	3.7
Average		64.9			46.8 (3.7–106.8)
2[a]—Yearling calves	83 calf	Over 365	None	Normal	0.0
	85 calf	Over 365	None	Normal	0.0
	91 calf	Over 365	None	Normal	0.0
	93 calf	Over 365	None	Normal	0.0
	94 calf	Over 365	None	Normal	0.0
	95 calf	Over 365	None	Normal	0.0
	96 calf	Over 365	None	Normal	0.0
	92 calf	Over 365	None	Normal	2.0
	99 calf	Over 365	Weak	Nephrosis	0.0
	81 calf	Over 365	Blindness	Nephrosis	3.7
	84 calf	Over 365	None	Nephrosis	1.8
	89 calf	Over 365	Unthrifty	Nephrosis	1.9
Average		Over 365			0.8 (0.0–3.7)

[a] Slaughtered.
[b] Died.

The first suspicion that the calves might be taking toxic material arose when they were observed chewing the corral fence. The cows and calves were in adjacent lots except when nursing. The chewing of the fence was extensive, in some cases the boards being nearly chewed in two. The fence had been painted about three years prior to the time of the highest incidence of trouble and was considerably weathered when the calf symptoms were pronounced. Scrapings from the fence showed a high content of lead. It seemed desirable to investigate the possibility that lead was an etiological factor in the production of the calf symptoms. In order to obtain control data, livers and kidneys were obtained from five cows and five calves at the local slaughter house. Lead determinations were made on the livers, and kidneys were ex-

amined for pathological changes. The results are presented in table 1. All the kidneys appeared normal and the livers contained very small amounts of lead or none.

The experimental calves were divided into two groups (1) those that exhibited symptoms of the disease early in life while nursing their dams, and (2) those about one year old, some of which had recovered from previous symptoms. All except one of the younger calves in the first group showed clinical symptoms that were more or less characteristic (table 1). These symptoms consisted of convulsions, blindness and lack of thrift, followed by

TABLE 2. EFFECT OF ADMINISTRATION OF LEAD TO CALVES ON SYMPTOMS AND LEAD CONTENT OF THEIR LIVERS

Calf	Source	Age at start of experiment	Days[1] on treatment	Total lead ingested	Clinical symptoms	Autopsy findings	Lead in dry liver
		Days	*Days*	*Grams*			*Mg 1 Kg*
1	Beef herd	68	24	22	Convulsions	Nephrosis	55
2	Dairy herd	21	6	21	Convulsions	Nephrosis	454
3	Swine farm	20	9	9	Convulsions	Nephrosis	56
4	Swine farm	14	19	10	Convulsions	Nephrosis	514
5	Dairy herd	22	30	47	None	Nephrosis	381
Average		29	17.6	21.8			292

[1] All calves died.

death. At autopsy, seven of the eight calves showed various stages of kidney changes. The one that did not show kidney damage had only a small amount of lead in the liver. Of the seven that showed kidney changes, six had abnormally high amounts of lead in the liver. The evidence strongly suggests that lead was responsible for the clinical symptoms and kidney damage.

Most of the older calves of group 2 showed no symptoms during early life, but a few were mildly affected. These were fattened in the usual way and examined at slaughter when about one year old (table 1). There were twelve calves in this group, three of which had shown clinical symptoms. All three showed evidence of nephrosis and lead was found in the livers of two although not in as high concentration as in the calves that had shown more serious symptoms earlier in life. One animal in which no clinical symptoms had been observed showed evidence of nephrosis, and lead was found in the liver. Nine animals showed no clinical symptoms, had normal kidneys, and their livers were free of lead. This furnished additional evidence of the role of lead in producing kidney damage and clinical symptoms in calves used in beef production experiments.

Since the foregoing exprrience, care has been taken to prevent the calves

in the beef production experiment from chewing the fence. No symptoms developed in the calves and no death losses were experienced thereafter. Unfortunately, slaughter material from these later calves was not made available for study, hence no statement can be made relative to the condition of the kidneys and the lead content of the liver.

Since it seemed likely that these animals had been suffering from lead toxicosis, an attempt was made to reproduce the symptoms by the administration of lead compounds to normal calves. Five calves were used in this study. They were from 19 to 68 days old when placed on experiment and were bucket-fed on milk. The results of the experiment are shown in table 2. The lead compound (lead acetate in the first case and the carbonate in the others) was administered over a period varying from 6 to 30 days in doses of from 0.5 to 6.0 grams daily. Convulsions developed in four of the five cases and all the animals died. The total amount of lead (as the element) fed before death occurred was from 9 to 47 grams (average 21.8 grams). Autopsy showed nephrosis in all cases and a tendency toward edema of the brain and spinal cord in most cases. The livers contained from 56 to 514 mg. of lead per kg., dry basis (average 272 mg.). Although this was somewhat more lead than was found in the beef-production experimental calf livers, in two cases about 55 mg. was found which was about the amount found in the experimental calves. The over-all picture produced by the administration of known amounts of lead to normal calves was strikingly similar to that observed in the beef production experimental calves. Giltner (1942) in discussing paint poisoning in livestock reports that cattle are more susceptible to lead than other animals and that calves are especially sensitive. In addition, he states that "cattle are poisoned by lead paint much more often than most people realize."

The differential diagnosis of diseases which cause nervous symptoms and death in cattle is very difficult. Toxic conditions, such as lead poisoning, sometimes cause symptoms which are clinically indistinguishable from those resulting from infectious encephalitis and meningitis. Chemical analyses of organs was of help in effecting an accurate diagnosis in these experiments.

Summary

1. Data are presented which indicate that experimental calves were poisoned as a result of chewing a fence painted with lead paint.

2. The symptoms found in these experimental calves were reproduced in calves that had received known amounts of lead.

3. Cows and calves from the local slaughter house had livers containing little or no lead and normal kidneys.

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ALTERATION OF THE ESTRUAL CYCLE BY PITUITARY GONADOTROPINS AND PERSISTENCE OF THE EFFECTS UPON REPRODUCTIVE PERFORMANCE IN EWES[1]

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ON THE basis of chance, approximately six or seven percent of the ewes in a flock should be in heat each day during the active breeding season. There would be some advantage in artificial insemination if an entire flock could be inseminated in a single day or at least in less than a sixteen- or seventeen-day period. There would also be a gain in uniformity of the lamb crop if the breeding season could be shortened by having all ewes come into estrus at approximately the same time.

There appear to be two possibilities in bringing about this regulation of the estrual period. One would be the induction of ovulation and the initiation of pregnancy as the direct result of treatment with gonadotropic hormones. This presumes that ovulation of potentially-fertile eggs would be brought about irrespective of the stage of the estrual cycle at the time of treatment. The work with pituitary gonadotropins thus far holds out little hope of such results (Casida, Warwick and Meyer, 1944; Murphree, Warwick, Casida and McShan, 1944). Fertility of the eggs was not obtained when the ewes were treated early in the estrual cycle and although the eggs were fertile when termination of treatment coincided with natural estrus, the large embryonic mortality makes the value of the treatment questionable. It should be emphasized that large doses of gonadotropins were used in these studies and the results need to be checked further on small dosages.

Another possibility for reducing the variation in the day the different ewes of a flock are in heat might be to treat them all at the same time and induce the formation of new corpora lutea. The natural rhythm of the estrual cycles could be altered perhaps in such a way that all ewes might take as their time of departure the formation of the new corpora lutea and accordingly be in heat 16 or 17 days later. One object of the present study has been to test this possibility.

The studies of Zavadovskii, Wunder, Paduceva and Margvelasvili (1935) and Zavadovskii, Eskin and Ovsjannikov (1935) suggest that there is little likelihood of being able to alter the rhythm of the estrual cycle in sheep and cattle. They found that treatment of the animals during the estrual cycle did

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[2] The authors acknowledge the kindly assistance of Dr. W. H. McShan of the Department of Zoology for the preparation of the extracts and of R. L. Murphree and E. J. Warwick of the Department of Genetics for aid in conduct of the experiment.

not prolong the time until the next heat period. Some work with cattle, however (Casida, Meyer, McShan and Wisnicky, 1943), has suggested that treatment during the early part of the estrual cycle may prolong the time until the next heat period if unfractionated extracts of the anterior pituitary are used, but probably do not do so if purified follicle-stimulating extracts are used.

Consideration has been given in the present study to the after-effects of treatment with gonadotropic hormones upon reproductive efficiency. A comparison also has been made of the biological effects of two kinds of extracts of the anterior pituitary gland upon the estrual cycle and the estrual period.

Plan of the Experiment

Thirty grade Wisconsin ewes, purchased in September, 1942, were included in this study. Each animal went through one complete estrual cycle after entering the experimental flock before treatment was begun. Control data for each animal were thus furnished on the lengths of one estrual cycle and one estrual period. The occurrence of estrus was determined by checking twice daily with a teaser ram.

The ewes were divided into six groups of five animals each. Three of the groups received subcutaneous injections of an unfractionated pituitary extract[3] and three other groups received subcutaneous injections of a purified follicle-stimulating extract[4] of the pituitary gland. Of the three groups on each extract the subcutaneous injections were started on the fourth, eighth, and twelfth day, respectively, of the estrual cycle. Thus there were two treatment groups at each of three stages of the estrual cycle.

A standard treatment consisted of four subcutaneous injections given on succeeding days. The total dosage administered subcutaneously was 30 gram-equivalents in the case of the follicle-stimulating extract and 4.8 gram-equivalents in the case of the unfractionated extract.

On the second day after the last subcutaneous injection of either extract an intravenous injection of unfractionated extract was given. The intravenous dosage was one-gram-equivalent if the subcutaneous injections had been follicle-stimulating extract and 1.2-gram-equivalents if the subcutaneous injections had been unfractionated extract. Thus half of the ewes received 30 gram-equivalents of follicle-stimulating extract subcutaneously and one gram-equivalent of unfractionated extract intravenously. The other half of the ewes received a total of 6 gram-equivalents of unfractionated extract, 4.8 gram-equivalents of it subcutaneously and 1.2 gram-equivalents intravenously.

The ewes were inseminated at the first heat period which was initiated

[3] "B" fraction prepared by the method of McShan and Meyer, 1943.
[4] Prepared by method of McShan and Meyer, 1940.

following the close of the injections. In case the animals did not conceive on the first insemination, repeated breedings were made during the experimental period. All the animals were slaughtered 68–73 days after the beginning of injections; the number of lambs and the state of the reproductive organs of the ewes were determined at the time of slaughter.

The follicle-stimulating extracts used in this experiment produced ovaries weighing an average of 85 mg. in immature rats when injected subcutaneously into 21-day old animals, twice daily, for four and one-half days—total dosage 500 mg.-equiv. A similar assay of 50 mg.-equiv. of the unfractionated extract produced ovaries weighing an average of 78 mg. The former extract produced nothing but follicular development in the rat ovaries, whereas the latter extract produced follicular growth and marked luteinization.

A preliminary study four days after treatment of three ewes receiving the standard dosage of the follicle-stimulating extract showed the formation of 34, 2 and 21 corpora lutea, respectively; also 19 corpora lutea were found in a fourth ewe receiving one-third the dosage. One ewe was given a treatment involving the standard dosage of unfractionated extract and four days after the end of treatment she showed five corpora lutea, 15 mature follicles and six cysts.

Results and Discussion

Effects Upon the Inter-Estrual Interval

The efficacy of treatment in controlling the time of the next estrual period may be seen by considering that on a given day when treatments were started all ewes could be placed into one of three categories, either 4, 8 or 12 days since the beginning of the last estrual period. The treatment terminated five days later, that is, 9, 13 or 17 days after the beginning of the last estrual period. Had the variation in the length of the interval from the termination of treatment to the time of the next estrus been decreased over that which would be predicted from a knowledge of the control estrual cycles, assuming that treatment had no effect?

The over-all variation in the intervals following treatment with either extract (table 1) gave no evidence of an increase in uniformity. In fact, the variances were increased numerically, and following treatment with an unfractionated extract was increased to a degree that was highly significant statistically (282.3 as compared to 22.0, each calculated on 15 animals). Most of the variance in the control data was of an artificial character due to the selected stages of the estrual cycle. Relatively little of it arose from variation within stages. This is in contrast to the situation with the experimental intervals, particularly in the groups treated with unfractionated extracts, in which the differences between stages were altered little from the controls

(ranges from highest to lowest means, 16.1 and 10.9, respectively) and there was a highly significant increase in the "within-stage" variation over that of the controls in every group. Clearly, then, neither the follicle-stimulating nor the unfractionated extract gave any practical gain in controlling the time of estrus so that variation in the time of breeding could be decreased.

The increased variation in the interval from end of treatment until next estrus is due largely to the effect of treatment on the length of the experimental estrual cycle (the estrual cycle in which treatment was begun). Considering first the three groups that were treated with unfractionated extract, we find that both the mean lengths of the cycle and the variances are increased greatly (table 2). In no case was the average experimental cycle

TABLE 1. EFFECT OF TREATMENT ON LENGTH AND UNIFORMITY OF INTERVAL FROM END OF TREATMENT UNTIL NEXT ESTRUS

Interval	Stage of treatment							
	4-day		8-day		12-day		All	
	Mean	*Variance*	*Mean*	*Variance*	*Mean*	*Variance*	*Mean*	*Variance*
Predicted from control	7.8	0.2	3.9	0.4	14.8	0.2	8.8	22.0
Observed following treatment with Unf. Ext.	25.5	457.1	31.4	338.0	15.3	27.2	24.1	282.3
Predicted from control	7.7	1.1	3.5	0.4	15.4	0.8	8.8	26.7
Observed following treatment with FSH Ext.	8.7	0.6	9.4	82.8	17.0	17.1	11.7	43.8

shorter than the average control cycle. For individual animals, the prolongation varied from one day to as much as 54½ days. (This last case had not been in heat up to the time of slaughter but for purposes of handling the data her estrual cycle was considered as terminating at that time.) Statistically there were no differences in the lengths of the experimental cycles of the different stage-groups. Establishment of such differences, however, would be very difficult because of the tremendous intra-stage variation.

It is believed that there are at least two factors which contribute to the prolongation of the experimental estrual cycles. They are based on two characteristics of the response from unfractionated extracts which have been observed with sheep in this laboratory: (1) the formation of new corpora lutea may continue for some time after the termination of treatment; and (2) in addition to the formation of large numbers of corpora lutea, there is the formation of cystic follicles and luteinized cysts.

Although, as is now suspected, each experimentally produced corpus luteum may not be the physiological equal of a naturally-produced corpus

luteum in its effect on the estrual cycle, the continued formation of new corpora lutea may well prolong the cycle. The animal mentioned above, which had not yet had a heat period after 71 days of cycle-length, showed at the time of autopsy 18 corpora lutea in the right ovary ranging from 8 to 10 mm. in diameter. The left ovary showed only remnants of old corpora lutea. The uterine walls in this animal were thin and appeared to be atonic in character. Approximately one-half pint of fluid was enclosed in the uterus.

It is not known what effect cystic follicles and luteinized cysts would have on the length of the estrual cycle or whether both would have the same effect. It is suspected, however, that the over-all result would be one of prolongation of the cycle.

The effects of treatment were not nearly so marked in the three groups

TABLE 2. EFFECT OF TREATMENTS ON LENGTH OF ESTRUAL CYCLE

Cycle	Stage of treatment					
	4-day		8-day		12-day	
	Mean	*Variance*	*Mean*	*Variance*	*Mean*	*Variance*
Control	16.8	0.2	16.9	0.4	15.9	0.1
Unf.—Expmtl.	34.5	457.1	44.4	338.0	29.3	74.4
Control	16.7	1.7	16.5	0.4	16.2	0.2
FSH—Expmtl.	17.7	0.6	22.4	82.8	15.9	0.2

that received the follicle-stimulating extract. The variances (table 2) were not affected except in the group treated at the 8-day stage, where it was increased markedly over the control. The individual experimental cycles for the 4-day group were in all cases the same length as the control cycles or longer, but the prolongation is obviously slight and is not statistically significant. The average length of the experimental cycles in the 12-day group likewise shows no significant decrease over that of the controls. Altogether the treatment with follicle-stimulating extracts seems to have been much less disturbing to the 4-day and 12-day groups than to the 8-day group.

One animal from the group treated at 8 days with follicle-stimulating extract gave a clue at the time of autopsy to the nature of the physiological disturbance causing the variation in her group. This one animal had shown a heat period at the end of a 15-day experimental estrual cycle. She had shown no other estrual period up to the time of autopsy 63½ days later. Fourteen corpora lutea, 5 to 10 mm. in diameter, were present in the left ovary when she was slaughtered. The right ovary showed only remnants of 11 old corpora lutea. The uterus had the same general appearance as that of the ewe mentioned above that had been treated with unfractionated extract at four

days in the estrual cycle. There was a similar atony of the uterine wall and the inclusion of a quantity of yellowish fluid in the uterus.

It is believed from observations in this laboratory that the follicle-stimulating extracts are much less likely than the unfractionated extracts to cause the formation of new corpora lutea over an extended period of time, or to cause the formation of cystic follicles and luteinized cysts. These observations have been made when treatment has been given either early or late in the estrual cycle and harmonize with the relatively mild disturbance of the estrual cycle when treatment was begun at the 4- and 12-day stages. Little is known, however, about the reaction when treatment is given in the mid-cycle. It seems likely from the disturbance of the estrual cycle that there is a tendency for the effects on the ovaries to be more prolonged than when given early or late in the cycle.

Effects Upon the Estrual Period

The most striking effects of treatment upon the ensuing estrual period were found in the 4-day and 8-day groups treated with either type of extract (table 3). The average period was decreased from the control length by .3 to

TABLE 3. AVERAGE LENGTH OF ESTRUAL PERIODS (DAYS)

Estrual periods	Stage of treatment		
	4-day	8-day	12-day
Control	1.3	1.4	1.4
Unf.—Expmtl.	1.0	1.1	1.1
Control	1.3	1.4	1.3
FSH—Expmtl.	0.9	1.1	1.6

.4 of a day, or approximately 20 to 25 percent. At the 12-day stage, however, the effect of treatment depended upon the type of extract which was used. Again the unfractionated extracts showed a decrease of .3 of a day, but the follicle-stimulating extracts showed an increase of .3 of a day. The decreases in the three stages for the treatment with unfractionated extracts were statistically significant (table 4; effect of treatment). The significant interaction between "stage and treatment" (st. × tr.) with follicle-stimulating extract indicates the reverse relationship between length of control and experimental periods in the 12-day stage as compared to the 4- and 8-day stages.

Estrus did not occur during the course of treatments begun at the 4- and 8-day stages. When it did occur, it was presumably in the presence of a rather large amount of regressing luteal tissues resulting from the treatment.

The treatment at the 12-day stage was going on during the time of regression of the natural corpus luteum from the last heat period and the development of a new follicle or follicles. Treatment with the unfractionated extract appeared to suppress in all, save possibly one animal, the natural heat period. Treatment with the follicle-stimulating extract, on the other hand, did not suppress the natural heat period, but seemed to accelerate the time of its beginning. The acceleration which was noted here, however, did not result in so long a heat period as had been noted previously (Warwick and Casida, 1943). A possible explanation of this difference lies in the fact that the con-

TABLE 4. ANALYSIS OF VARIANCE IN LENGTH OF ESTRUAL PERIODS

Source of variation	Unfractionated extract			FSH extract		
	D/F	Mean sq.	F	D/F	Mean sq.	F
Treatment[1]	1	0.67	6.1*	1	0.13	1.3
Stages	2	0.04	0.4	2	0.31	3.1
Stages×Treatments	2	0.00	—	2	0.36	3.6*
Error	23	0.11		24	0.10	
Total	28			29		

* P=0.05–0.01.

[1] I.e. between experimental and control periods.

trol estrual cycles in the previously reported sheep were longer than they were in the experiment being reported. Treatment was begun at the same day of the estrual cycle in both cases. The interval from the time that the hormone began to exert its effect until the potential time of onset of the natural estrus would consequently be shorter in the group with the inherently shorter estrual cycles. Thus, there would be less acceleration to the beginning of estrus and less increase in length of the estrual period.

The suppression of estrus at the time it should have occurred naturally in the 12-day group, treated with unfractionated extract, could be explained by the likelihood that luteal tissue was being formed early in the treatment and just before the time for onset of natural estrus. The first luteal tissue to be formed with follicle-stimulating extracts, on the other hand, was probably after the intravenous injection.

Effects Upon Subsequent Fertility

The fertility of the ewes, beginning at the first heat period following the completion of treatment, gives some additional information on the persistence of the effects of treatment on reproductive physiology (table 5). Only four of the ewes treated with the unfractionated extract at the 4-day stage were inseminated. The other ewe, as noted above, had not been in heat at the

time of slaughter. Two of the four ewes conceived at the first insemination, three finally became pregnant, and three lambs were present at slaughter. In contrast to this, there appears to have been little deleterious effect of treatment with the follicle-stimulating extract at the same stage. All five ewes were bred and conceived at the first insemination and six lambs were present at slaughter.

The performance of the ewes treated at the eight-day stage was relatively poor, whether treated with unfractionated or follicle-stimulating extracts. One of the ewes on the former extract was not bred. She came into heat only

TABLE 5. FERTILITY OF EWES FOLLOWING TREATMENT

Stage	Treatment	No. bred	Conceived on first insem.	Total no. insems.	No. pregnancies	No. lambs
4-day	Unf.	4	2	6	3	3
	FSH	5	5	5	5	6
8-day	Unf.	4	3	6	3	4
	FSH	5	1	8	4	4
12-day	Unf.	5	3	8	4	5
	FSH	5	4	6	5	6

a few days before slaughter and no attempt was made to inseminate her. Three of the four other ewes on unfractionated extract conceived on the first insemination. Four lambs were present at autopsy. On the follicle-stimulating extract, however, only one of the five ewes conceived on the first insemination. Altogether four of them conceived and were carrying four lambs.

The ewes treated at the 12-day stage were, in general, more comparable in their performance to those treated at the 4-day stage than to those at the 8-day stage. Again one ewe on the unfractionated extract did not conceive. Three of the four pregnancies following treatment with that preparation were conceived at the first service, and five lambs were present at autopsy from all four pregnancies. All the ewes on the follicle-stimulating extract conceived, four of them to the first insemination. Six lambs were present when the ewes were slaughtered.

The breeding results following treatment seemed, then, to be very closely associated with the degree of the disturbance shown previously in the experimental estrual cycle, the least deleterious effect being shown by the ewes in the 4- and 12-day stages treated with follicle-stimulating extract.

Another way in which the effect of treatment might be reflected in the later pregnancies of the ewes would be in the physiology of the uterus. The normality of the appearance of the fetuses and fetal membranes and the location of the fetuses in the uterus were examined. No abnormalities of the fetuses and probably none of the fetal membranes were noted. There appeared to be excessive congestion of the blood vessels at the edges of the cotyledons in some cases and even slight hemorrhage, but it could not be determined whether this condition occurred previous to or at the time of slaughter.

Observations on the location of the fetuses in the uterus were made and evidence was found which indicated that migration from one uterine horn to the other had occurred with 6 of the 28 fetuses. One of these cases was rather striking in which the two corpora lutea of pregnancy were in the right ovary and both fetuses were lying in the left uterine horn. The membranes were definitely attached in the left horn but were not yet visibly attached in the right horn. There were also two cases of migration in single pregnancies and two cases of migration of one lamb in twin pregnancies. The proportion of migration observed in this study appears to be in line with the observations of Curson (1934), who found 4 migrants among 46 lambs, and also with those of Cloete (1939), who found 8 migrants among 36 lambs. Thus no evidence was obtained at the time of slaughter that the effects of treatment had carried over to affect the physiology of the pregnant uterus.

Summary

The effects of two gonadotropic extracts of the pituitary gland were compared when administered to ewes in three stages of the estrual cycle—fourth, eighth, and twelfth days. Four subcutaneous injections of follicle-stimulating extract in one case and of unfractionated extract in the other were used, each being followed by one intravenous injection of unfractionated extract. Thirty ewes were studied in the experiment.

Treatment with unfractionated extract increased both the length and variation of the estrual cycles during which treatment was begun. There was no evident effect of follicle-stimulating extract upon the current estrual cycle when treatment was begun on the fourth or the twelfth days; the variation was increased, however, when treatment was begun on the eighth day of the cycle.

Treatment with either extract shortened the first estrual period subsequent to the end of treatment in the four- and eight-day groups, but in the twelve-day groups the periods were shorter for the unfractionated and longer for the follicle-stimulating extract than for the controls.

Ten ewes conceived from 20 inseminations among the 15 animals receiving

unfractionated extract and 14 ewes from 19 inseminations among a like number receiving follicle-stimulating extract. Breeding was begun at the first estrus subsequent to the end of treatment.

Neither extract gave any practical gain in controlling the time of estrus so that variation in the time of breeding could be decreased. In general, greater physiological disturbances followed the use of unfractionated than of follicle-stimulating extract.

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THE NECESSITY OF THE CORPUS LUTEUM FOR MAINTENANCE OF PREGNANCY IN THE EWE[1]

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THE presence of corpora lutea has been found necessary for the maintenance of pregnancy throughout most if not all of gestation in the rabbit (Corner, 1928), the rat (Johnson and Challans, 1930), cow (Hammond, 1927, Sartoris, 1938), and goat (Drummond-Robinson and Asdell, 1926). In other species including man (Asdell, 1928), monkey (Hartman, 1941), guinea pig (Loeb, 1923), and the mare (Hart and Cole, 1934), it has been found possible to remove the ovaries before the end of gestation without interrupting pregnancy. It has been assumed that there is some extra-gonadal source of progestin in the animals in which the corpora lutea and ovaries can be dispensed with during pregnancy.

No evidence seems to have been cited in the literature regarding the effects on the ewe of removal of the corpus luteum of pregnancy. Grant (1934) found that the size and color of the corpus luteum was maintained until the 18th week of pregnancy, after which there was some degeneration until parturition. If there is any gross degeneration of the corpus luteum, however, it does not appear to be reflected by changes in weight of the ovary during the latter part of pregnancy (Cloete, 1939).

Experimental Procedure and Results

Eleven pregnant ewes were laparotomized under nembutal and ether anesthesia and both ovaries were removed from 9 of them (table 1). The corpora lutea of pregnancy were enucleated and the craters cauterized to stop bleeding in the other two ewes.

The results were not consistent at any given stage of pregnancy, and since no control operations were performed, it is impossible to estimate the proportion of abortions due to operative shock or trauma. Successful maintenance of pregnancy after spaying did not appear to be related to the size of the ewe or the number of fetuses. The results demonstrate that in at least some cases the ewe is capable of maintaining pregnancy in the absence of ovarian tissue or corpora lutea from the 55th day of gestation onward. Of the six ewes treated at the 30th to 77th days of pregnancy, two produced living lambs. These were ovariectomized at 55 and 64 days.

Although the data are too few for drawing conclusions, there is a suggestion that a higher proportion of ewes from which the corpora lutea or the

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ovaries had been removed at about the 100th day of gestation were capable of maintaining pregnancy than of those treated earlier. Four ewes were treated at 99 to 103 days of pregnancy and two of them produced normal liv-

TABLE 1. EFFECT OF OVARIECTOMY OR REMOVAL OF CORPORA LUTEA UPON PREGNANCY IN THE EWE

Ewe no.	Days pregnant when ovariectomized	No. of corpora lutea	Living lambs born	Remarks
2211	30[1]	1***	0	Aborted 2 days later—21 mm. fetus.
104	54*	2	0	Aborted 8 days later—10 cm. decomposing fetus.
128	55**	2	2	Some bloody discharge from vagina 11 days after ovariectomy; birth wt. of lambs 6¼ and 8 lbs.; at 53 days of age weighed 41 and 46 lbs.
137	64[1]	1	1	Birth wt. of lamb—10 lbs.; slaughtered.
119	66*	2	0	Aborted 8 days later—15 cm. decomposing fetus.
123	70[1]	2	0	Some fetal membranes found 9 days later; no fetus found but not pregnant at autopsy.
118	77[1]	1	0	Vaginal discharge 7 days later; no fetus found but not pregnant at autopsy.
2224	99**	1***	1	Birth wt. of lamb—7½ lbs.; slaughtered.
138	99**	2	2	Birth wt. of lambs 4½ an: 6½ lbs.; at 97 days of age weighed 51 and 60 lbs.
126	102[1]	2	0	Ewe sick during remainder of pregnancy—recovered after lambing. Two dead lambs weighing 6 and 7 lbs. born 35 days later. No decomposition.
125	103[1]	2	0	Aborted 2 days later; 2 fetuses of 30 and 32.5 cm.

[1] Interval from known breeding date.
* Estimated from length of aborted fetus according to standards of Winters and Feuffel (1936).
** Estimated from date of lambing assuming 148-day gestation.
*** Not spayed—corpora lutea removed from ovaries by digital pressure followed by cautery.

ing young. A third ewe (No. 126) became sick a few days after the operation, and remained ill until 35 days after ovariectomy, when she gave birth to two dead, but normal-appearing lambs, approximately normal in size for the 137th day of gestation. Immediately after lambing the ewe recovered. It seems reasonable to suspect that the illness was due to a toxemia of preg-

nancy, but whether or not removal of the ovaries had any part in the illness is not known. In spite of the sickness of the ewe, the lambs apparently lived *in utero* for at least a month after the operation.

All the ovariectomized ewes were later slaughtered and found to have no remaining ovarian fragments. The ewe whose corpus luteum had been expressed (No. 2224) and lambed normally, was slaughtered the day of lambing. Serial sections of the ovaries revealed no luteal tissue.

Only two ewes (Nos. 128 and 138) were allowed to nurse their lambs, but in both cases lactation was apparently normal as judged by the growth rate of the lambs. In each of these cases the ewes nursed twin lambs.

Summary and Conclusions

Normal lambs were produced by two of six ewes which were ovariectomized between the 54th and 77th days of gestation and by two (questionably three) of four ewes ovariectomized or subjected to corpora lutea removal between the 99th and 103rd days of gestation. A single ewe whose corpus luteum was removed at the 30th day of gestation aborted two days later. The results establish the fact that in at least some cases the ewe can maintain pregnancy without the presence of corpora lutea after the 55th day of gestation.

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MONTHLY CHANGES IN FINENESS, VARIABILITY, AND MEDULLATION IN HAIRY LAMBS

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TRUE wool is found in wild or primitive types of sheep only as a short undercoat concealed by long, coarse hair. The preponderance of true wool fibers in domesticated wool-producing breeds presumably is due to long continued selection. The fact that objectionable fibers having hairlike properties still are present in some wool sheep, particularly as lambs, indicates that the primitive coat has not been completely eliminated. In addition to the inherent tendency for particular follicles to produce certain types of fibers, the wide range of environmental conditions to which sheep are subjected may produce important changes in the character of the fibers.

Matthews (1904), Bowman (1908), Hawkesworth (1920), and Von Bergen and Krauss (1942) described and illustrated various types of animal fibers. Dry (1937, 1938) conducted studies on the inheritance of halo-hairs in lambs and concluded "you get that for which you breed." Wilson (1929) described different types of medullated wool fibers and reviewed the literature on this subject.

The nomenclature accorded various types of fibers has varied widely and has been influenced by the locality and kind of wool under investigation. In this study, dealing with lambs from docking time until yearling age, the fibers have been classified as (1) true wool fibers, (2) lamb hairs, and (3) medullated fibers. Monthly changes are reported in the frequencies of the three types of fibers, the mean fiber diameter and variability of a group of lambs selected because of their hairy appearance.

Materials and Procedures

About 2000 lambs were examined for hairiness during each of the three years covered by this study. The lambs were scored visually for hairiness according to extreme, moderate, slight or freedom from hair. The coarse, white hair on the lamb in figure 1 illustrates the appearance of a Rambouillet lamb scored extremely hairy. All lambs selected for the study scored hairy to some extent but not all of the most extreme lambs were used. The number and breed of the lambs studied in 1940, 1941, and 1942 are given in table 1.

The lambs were reared under typical intermountain range conditions, herded on the spring-fall sagebrush range near the station after lambing in the spring, and were moved to a higher elevation into the Targhee National

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Forest with the approach of summer. They were weaned in September and wintered on alfalfa hay. In the spring they were brought back to the station for grazing and shearing.

TABLE 1. THE YEAR, BREED, AND NUMBER OF LAMBS STUDIED

Year	Breed				Total
	Rambouillet	Targhee	Corriedale	Columbia	
1940	13	3	2	4	22
1941	7	1	6	11	25
1942	14	3	1	4	22

Small locks of wool were taken from the middle of the side, the thigh even with the underline, and the middle of the back. A dotted line was tattooed on each sampling location so samples from adjacent areas could be removed at monthly intervals. The first samples were taken when the lambs were between 30 and 65 days of age. The locks were clipped next to the skin with a pair of curved dissecting scissors and handled carefully so the fibers would not be disturbed from their original position. They were cleaned in carbon tetrachloride, dried, and cross-sectioned about one-half inch from the base of the lock of fibers.

Figure 1. A hairy lamb.

In 1940 the count method described by Hardy and Wolf (1930) was used to estimate mean diameter and variability. In 1941 and 1942 the rapid comparator method described by Pohle (1940) was employed. The percentage of medullated fibers was estimated throughout as described by Pohle (1941). The number of objectionable hairs on each cross-section was counted in 1941 and 1942. The total number of fibers on the cross-sections were not recorded but it usually ranged from 1500 to 2000.

Fibers can be classified from their cross-section images as belonging to one of the three general groups: (1) true wool fibers, (2) lamb hairs and (3)

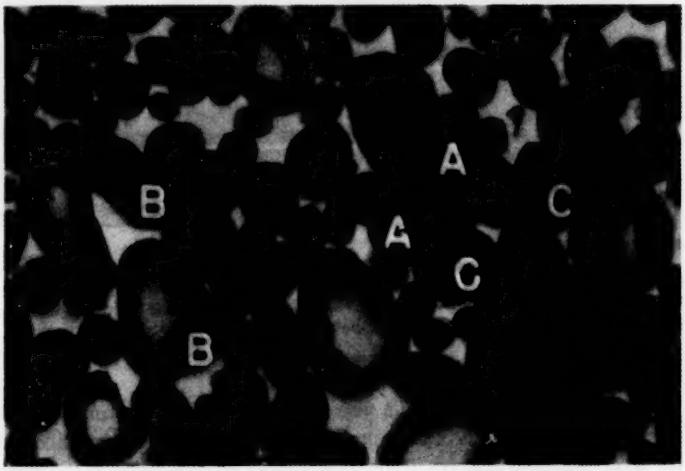

Figure 2. Cross section of fibers (340×) illustrating a first month's sample from a hairy Rambouillet lamb: (A) true wool; (B) lamb hairs; and (C) medullated fibers.

medullated fibers. Figure 2 shows the appearance of these groups in cross section. All the medullated fibers examined were of the fragmentary, interrupted or continuous type as illustrated by the longitudinal views shown in figure 3 (A, B, C, D). Consequently, a fiber which is medullated in some portions may be classified as either medullated or non-medullated when viewed in cross section, depending upon the particular level where the cross-section happens to be made. Most medullated fibers are generally larger in mean diameter than are true wool fibers for any particular grade of wool or breed of sheep, and it is difficult to say that some medullated wool fibers are not lamb hairs; however, not all lamb hairs have the continuous type of medullation throughout.

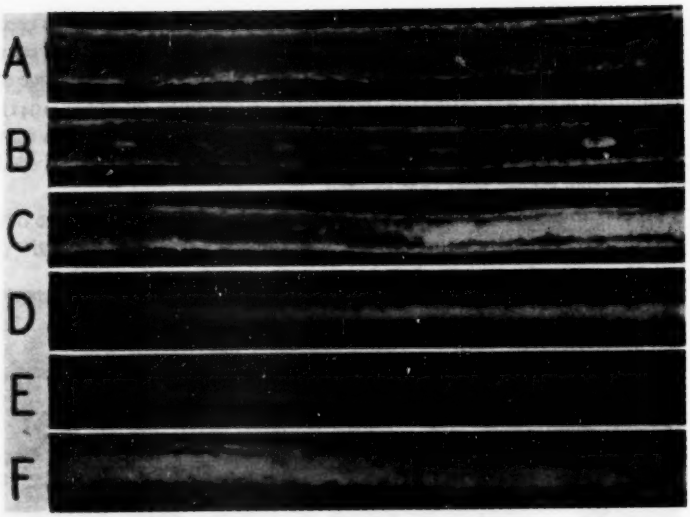

Figure 3. Longitudinal views of wool fibers at about 135×. A, True wool fiber. B, Fiber with fragmentary medulla. C, Fiber with interrupted medulla. D, Fiber with continuous medulla. E, View of a fiber between base and middle. F, View of same fiber as shown in E, between middle and tip.

Results and Discussion

The impression gained from a visual examination of hairy lambs is that the hairs constitute a fairly large proportion of the total number of fibers in the fleece. Monthly changes in the total number of hairs found in the cross-sections for the 47 lambs examined in 1941 and 1942 are given in table 2. Since approximately 1500–2000 fibers were examined in each cross-section, the number of hairs counted represents a small fraction of a percent of the 70,000–90,000 fibers which were examined each month. The greater length and coarseness and the oapque dead-white color of the lamb hairs as compared with the true wool fibers probably accounts for the impression of their high frequency that is given by visual examination. The striking feature in table 2 is the rapid disappearance of lamb hairs. Toward the end of the last sampling month certain locks of wool contained fibers that were curled up in the locks and they seldom gave a hairy appearance until stretched out. These curled fibers had a true wool appearance from the base to middle of the fiber but they were much more coarse and hairy appearing from the middle to the tip as illustrated in figure 3 (E, F). These fibers were often twice as long as the normal staple of wool. Since the cross-sections were made about

TABLE 2. TOTAL NUMBER OF LAMB HAIRS FOUND IN CROSS-SECTIONS FROM 47 HAIRY LAMBS

Location	Months sampled												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Side	132	113	28	3	0	0	0	0	1	1	0	0	276
Thigh	235	139	67	28	18	8	3	2	2	4	0	0	506
Back	238	128	67	14	16	5	1	8	0	3	4	2	486

one-half inch from the base of the staple on each monthly sample, the evidence seems clear that few, if any, lamb hairs were being produced by the fiber follicles when the lamb had reached a year of age.

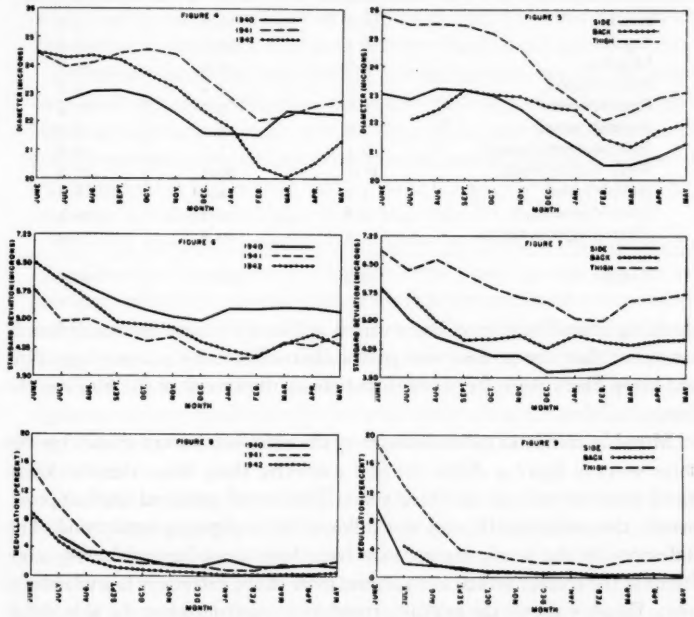

Figure 4. Monthly trends in mean diameter for 1940, 1941 and 1942.
Figure 5. Monthly trends in mean diameter for the side, thigh and back.
Figure 6. Monthly trends in variability for 1940, 1941 and 1942.
Figure 7. Monthly trends in variability for the side, thigh and back.
Figure 8. Monthly trends in percentage medullation for 1940, 1941 and 1942.
Figure 9. Monthly trends in percentage medullation for the side, thigh and back.

Fewer hairs were found on the side, and these were shed even more rapidly than those on the thigh or back. There was little difference in the number of hairs on the thigh or back or in the rates at which they were shed. While the lambs differed widely as to the number of hairs the first month or two, the presence of hairs was so sporadic thereafter that no statistical test was made to determine whether lambs lost their hairs at a uniform rate. No dependable evidence in the individual figures indicated that the rate of loss varied for different lambs. Grandstaff and Blunn (1944) found that the rate of

TABLE 3. PERCENTAGE OF TOTAL VARIANCE FOR DIAMETER, VARIABILITY, AND MEDULLATION IN 1942 ATTRIBUTED TO DIFFERENT SOURCES

Source	Diameter	Variability	Percent med.
Breed	35.7	10.7	3.0
Region	8.9	20.1	3.2
Months	20.6	10.5	15.1
Breed×region	0.6	3.4	3.6
Breed×month	2.0	2.3	11.4
Region×month	0.8	2.1	3.2
Breed×region×month	6.3	1.7	2.0
Sheep within breeds	15.1	20.7	10.2
Sheep×region	2.0	4.9	6.8
Sheep×months	2.8	4.1	29.1
Sheep×region×months	5.2	19.5	12.4
Totals	100.0	100.0	100.0

shedding coarse birth coat fibers varied in Navajo (a semi-improved breed) lambs and that the process was practically complete at 84 days of age. Hair and kemp fibers thereafter constituted about 18 percent of the fibers in the fleece.

Monthly trends in mean diameter of the cross-section are shown for the three years in figure 4. After the first 4 months, there was a definite downward trend in each of the three years. This trend persisted until approximately the ninth month, and was followed by a slight upward trend. The difference in the yearly curves may have been caused by including more lambs of the coarser breeds in 1941, and more of the extremely hairy lambs in 1942. Figure 5 shows the monthly trend in mean diameter at the side, thigh and back. The fibers of the thigh were about three microns coarser than those of the side and back the first few months and were from one to two microns coarser the last few months. The fibers of the back were finer than those of the side in the very young lambs but the decrease in average diameter was less so that they averaged about one-half micron coarser in the last several months.

The percent of the variance attributed to different sources of variation is given in table 3 for the 1942 data. Differences between breeds, months, sheep within breeds, and regions account for most of the differences in diameter. While the interactions account for less of the total variation, they indicate that the breeds do not follow exactly the same monthly trend and that individual sheep do not follow precisely the trend of the breed.

Monthly changes in variability of fiber diameter for each of the 3 years (fig. 6) show a uniform decrease for the first 7 or 8 months with a slight, irregular increase thereafter. The greater variability in 1940 may have been due to the difference in the methods of estimating variability used that year. The monthly trend in variability for the three regions is shown in figure 7. The variability of the thigh was greatest followed by the back, and side in that order. The trend in variability is fairly uniform for the three regions except that no increase was noted for the back during the last three months. The decline in variability is evident between the first and second months.

Differences between sheep within breeds, regions, breeds, and months were most important sources of variance in variability of diameter (table 3). Significant interactions indicated that sheep of the same breed did not follow uniform patterns in variability in the same regions or months. The remainder was considerably higher than that for mean diameter indicating that the estimate for variability was less reliable than that for diameter.

Monthly trends in percentage medullation for the three years (fig. 8) show a rapid decrease for the first few months, with a more gradual decrease until February and a slight increase thereafter. It is not certain why there was less medullation in 1942 than in the other years but this difference is obvious throughout the period. The fibers from the thigh were considerably more medullated than those from the side or back (fig. 9). The trends in the three regions were very similar for the first nine months but the medullation of the thigh fibers increased the last three months while that of the side and back did not.

The main sources of variation did not contribute greatly to the total variation in percentage medullation (table 3) except for differences between months. Most of the variation is due to important interactions between months and sheep or breeds. This analysis particularly indicates that medullation is a variable character, increasing and decreasing for individual sheep without closely following the general patterns shown in figures 8 and 9.

As shown by figure 2 the diameter of lamb hairs and medullated fibers within a breed is greater than that of the true wool fibers. The elimination of lamb hairs is apparently an inherent property of the follicles which produce them, and Dry (1938) and others have suggested that these may subsequently produce true wool fibers. It is evident that they do not again grow

fibers differing greatly from true wool fibers. The elimination of hairs coincides with the time of most rapid decrease in medullation and may result from a common cause. Longitudinal examination of yearling fibers under the microscope shows that most of the fibers having continuous medullation near the tip have either the fragmental or interrupted types near the middle and base of the fibers. This change in type of medullation probably accounts for much of the decrease in percentage medullation observed in the cross-sections.

The trends in mean diameter coincide with changes in environmental conditions known to have effects upon fiber diameter similar to those observed. For example, the decrease in mean diameter began about the time the lambs

TABLE 4. AVERAGES FOR HAIRY LAMBS AND THE ENTIRE GROUP FROM DATA TAKEN FROM THE SIDE AND THIGH AT YEARLING AGE

Group	Year	Mean diameter	Standard deviation	Percentage medullation
		(*Microns*)	(*Microns*)	
Hairy lambs	1940	22.3	5.14	1.94
	1941	22.8	4.77	2.64
	1942	21.4	4.56	0.53
	Average	22.2	4.82	1.74
Entire group	1940	22.7	4.68	—
	1941	23.4	5.23	1.50
	1942	20.9	3.95	0.76
	Average	22.4	4.65	1.15

were weaned in the fall, and continued while the lambs were under declining feed conditions during the fall and early winter prior to the winter dry lot feeding period. The lambs were placed in the feed-lot and fed alfalfa hay during the winter, after which time mean diameter increased. It is possible that changes in mean diameter may be normal functions of the follicles, due to feed conditions or other causes. Since no control group was kept under constant environment, a definite decision cannot be reached regarding this problem.

Samples were taken from the side and thigh before shearing of each of 2626 yearling ewes born in 1940, 1941, and 1942 and cross-sections were made of each sample. This date corresponds to the time at which the last cross-sections for the hairy lambs were made, and the techniques used in analyzing the cross-sections were identical. Table 4 shows the averages for the hairy lambs as compared to those for the entire group, the latter figures being weighted according to the breed composition of the group of hairy lambs each year. The entire group averages slightly coarser, slightly less variable and lower

in percentage medullation than the hairy lambs but the differences are not large in any case.

The study of these 69 hairy lambs failed to disclose any objectionable features as to hairiness, mean diameter, variability, and percentage medullation in the yearling fleeces of lambs scored as hairy at docking time.

Conclusions

The fleeces of 69 lambs classed as hairy at docking time were examined by the cross-section method at monthly intervals until yearling age at the U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory.

The number of hairs constituted only a small fraction of the total population, and these diminished rapidly as the lambs increased in age. Fewer hairs were found on the side than on the thigh or back.

Fiber diameter decreased between 6 and 11 months of age, showing a slight increase thereafter. This may have been due to weaning and subsequent poor feeding or to inherent properties of the fiber follicles.

Variability of fiber diameter decreased until about 11 months of age. Variability was greatest on the thigh and least on the side. Monthly trends in variability were similar for the side, thigh, and back.

Percentage medullation decreased very rapidly from two to five months of age and more slowly thereafter. A rather pronounced increase in medullation was noted on the thigh during the last three months. Medullation was not a constant property, varying considerably from month to month for individual lambs.

The yearling fleeces of the hairy lambs were compared to those of a much larger group most of which were classed as non-hairy at docking. No important differences were found in the yearling fleeces of hairy and non-hairy lambs as regards hairiness, mean diameter, variability or percentage medullation.

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GROWTH OF HORSES UNDER WESTERN RANGE CONDITIONS

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INFORMATION on growth and development of horses is very limited and no published records on growth under range conditions have come to the authors' attention. Results of a study of growth in weight and height and some of the factors affecting growth, under western range conditions, at the United States Range Livestock Experiment Station, Miles City, Montana, are reported in this paper. Growth in height and weight up to five years were adversely affected owing to inadequate nutrition and possibly other factors on range during the winter months. Height was affected less than weight. Details of these and other results are presented below.

Method of Managing the Horses Studied

A rather uniform system of breeding, feeding and management was followed for the animals used in this study. This included: (1) Mating of mares, three years of age and over, to foal in the month of May, whenever possible; (2) weaning of the progeny when about six months old; (3) inspecting and measuring of all growing stock twice annually (about April 15 and October 15); (4) Keeping foals with dams on pasture without supplemental feed until weaning; (5) feeding weanlings throughout the winter on adequate rations of grain and hay (about one pound of grain per each 100 pounds of body weight plus all the hay desired); (6) carrying all growing stock between one and three years of age on range pasturage except in emergencies; (7) Carrying non-working and dry mares on range pasturage without supplemental feed except in emergencies; (8) feeding working mares and geldings enough during work periods to maintain fit condition; (9) maintaining stallions on feed at headquarters throughout the year, except light stallions kept on range during the breeding season.

Material

Growth data are reported in this study on 297 horses which were foaled from 1927 to 1934, inclusive. Of these, 16 were Belgians; 59 were grade-draft horses (ranging from one-half to nearly pure Belgian); 75 were Morgans; and 147 were classed as grade-light horses (table 1). Some of the last group were sired by Thoroughbred stallions; others by Morgan stallions; and a few by

[1] Bureau of Animal Industry, Washington, D. C. The authors acknowledge assistance of J. R. Quesenberry, superintendent of the United States Range Livestock Experiment Station, and E. B. Osborn, who was directly responsible for collection of the data.

[2] This work was conducted cooperatively by the Bureau of Animal Industry and the Montana Agricultural Experiment Station.

a grade-Standardbred stallion. The mares used to produce the grade-light horses were, for the most part, western saddle stock of unknown breeding, but many obviously carried some improved light-horse blood, and this group also included offspring of a few Morgan mares mated to Thoroughbred stallions.

All the draft horses were sired by one Belgian stallion. This horse had a height of 66 inches (16-2 hands) and a weight of 1,850 pounds when in good breeding condition. Four Thoroughbred stallions were used. They ranged from 950 to 1,225 pounds in weight and from 61½ to 64½ inches in height. Data were available on but three of the four Morgan stallions used. These ranged from 1,040 to 1,150 pounds in weight and 60¾ to 62½ inches in height. The fourth Morgan stallion was sold before attaining mature size after siring only a few colts. The same Morgan stallions were used to sire the Morgans and part of the grade-light horses. With one small exception, only one stallion of a breed was used in any one year, making it impossible to compare the progeny of different sires within the same breed and year.

The fact that the same sire was used for the Belgian and grade-draft groups undoubtedly tended to make those groups more alike than if different sires had been used. A similar likeness existed between the Morgans and grade-light horses sired by the same Morgan stallions.

The Morgan stallions used at Miles City, Montana were similar in breeding to those used at the United States Morgan Horse Farm, Middlebury, Vermont. Two were sired by Mansfield (7255 A.M.R.), a stallion used extensively in the stud at Middlebury, and two were his grandsons. The mares at the two stations were not so closely related, but the breeding of the young stock appeared sufficiently comparable to justify comparison of growth rates under the widely different environments of the two places.

Data and Discussion

As judged by comparison with the results of other investigations, data obtained on the animals in this study show that they grew normally from birth to weaning and from weaning to one year, during which times they received adequate rations. They grew normally also in the 12- to 18-months period, when generally they were receiving sufficient feed from summer pastures. Between 18 months and two years of age, however, that is, the first winter they had to depend entirely on the range, all groups lost from 6 to 101 pounds on the average. The following summer all groups gained rather rapidly, but lost again during the third winter. Generally, the same fluctuation was found in the fourth and fifth years although not as great and not in all groups. The growth curves are shown in figure 1. Since the number of horses at the different ages was not the same, and in some of the groups was quite

TABLE 1. NUMBER OF ANIMALS USED IN THE STUDY, AT THE DIFFERENT AGES IN THE VARIOUS BREED AND SEX GROUPS

Breed group	Sex	Age									
		Weanling	1 year	1½ years	2 years	2½ years	3 years	3½ years	4 years	4½ years	5 years
Belgian	M	7	4	4	3	3	3	3	3	3	2
	F	9	9	9	9	9	5	5	4	3	2
Grade draft	M	26	25	24	21	19	14	14	11	10	6
	F	33	32	30	30	30	27	27	21	21	17
Morgan	M	38	37	31	26	22	15	10	3	3	2
	F	37	36	36	32	32	23	23	14	14	12
Grade light	M	80	76	72	70	67	61	61	38	32	17
	F	67	62	60	60	59[1]	50	50	35	33	28
Total		297	281	266	251	241	198	193	129	119	86

[1] Only 58 were available for the study of weight.

TABLE 2. AVERAGE WEIGHTS AND HEIGHTS, AT DIFFERENT AGES, OF THE VARIOUS BREED AND SEX GROUPS[1]

Weight (pounds)

Breed group	Sex	Age									
		Weanling	1 year	1½ years	2 years	2½ years	3 years	3½ years	4 years	4½ years	5 years
Belgian	M	618	985	1173	1072	1325	1228	1400	1385	1483	1520
	F	599	937	1059	1026	1221	1242	1455	1409	1452	1518
Grade draft	M	582	948	1053	1043	1274	1237	1418	1440	1524	1512
	F	615	970	1060	1054	1289	1083	1419	1392	1480	1482
Morgan	M	414	620	793	758	867	807	951	868	995	1065
	F	407	594	686	649	836	745	916	864	988	933
Grade light	M	420	630	753	702	906	825	983	960	1087	1041
	F	425	621	720	680	876	785	960	910	1020	978
Height (inches)											
Belgian	M	51.8	56.5	59.2	59.3	60.8	61.2	61.1	62.7	62.8	64.0
	F	52.1	55.9	57.9	58.9	60.3	61.6	61.8	61.6	61.9	62.0
Grade draft	M	52.0	57.1	59.1	59.9	61.8	62.6	63.4	64.0	63.8	65.0
	F	51.9	56.8	58.9	59.4	61.5	61.8	62.2	62.6	62.8	63.1
Morgan	M	49.5	53.5	56.3	56.9	58.3	59.0	59.9	60.0	60.1	61.4
	F	49.0	52.4	54.8	55.6	57.3	57.5	58.2	58.3	58.9	58.5
Grade light	M	50.1	54.3	56.8	57.2	59.3	59.5	60.6	60.8	61.5	61.8
	F	50.0	53.8	56.3	56.7	58.6	58.3	59.4	59.3	59.9	59.6

[1] For numbers of horses see table 1.

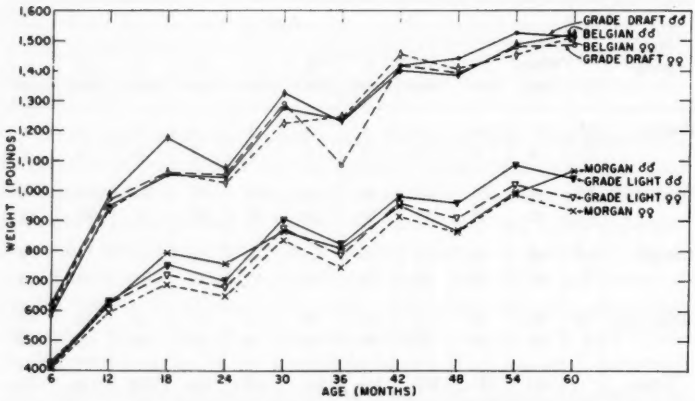

Figure 1. Growth in weight of horses under range conditions, by breed groups (see table 1 for numbers involved).

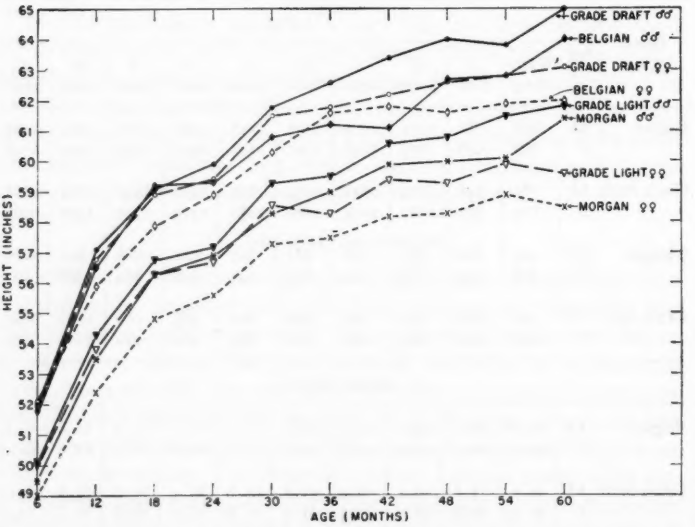

Figure 2. Growth in height of horses under range conditions, by breed groups (see table 1 for numbers involved).

small (see table 1), caution must be used in drawing definite conclusions, particularly with regard to small deviations in the growth curves. For example, the apparent increases in weight found in the fifth winter for the Belgian and Morgan males were due to the averages being increased by the loss of the smallest animals in those groups, rather than to other factors.

The weights of the horses after three years of age were not as representative of true weights as those before that time, as many of the mares were pregnant part of the year and some horses were worked or ridden, and given extra feed while performing such work.

Growth of the horses in height shows the adverse effects of inadequate feeding in winter periods (figure 2, table 2), but not to the same extent as growth in weight. Height is largely a skeletal measurement and would show little, if any, loss during periods of insufficient feed.

In most of the groups the males tended to be taller and heavier than the females and to mature a little more slowly, as shown by their growth curves, which do not flatten out as quickly as those of females. However, on the basis of increases in height and weight and under the feeding and management conditions in this work, there does not appear to be any evidence that the draft horses matured more rapidly than the light horses, as has sometimes been claimed (Gay, 1932; Harper, 1913).

There was a definite tendency for the method of management used in these experiments to produce horses that matured, as judged by their size at 5 years, somewhat below the size to be expected, if they had been fed adequately during all stages of the growing period. This is indicated by comparison with data obtained on groups of draft colts fed at Columbia, Missouri (Trowbridge and Chittenden, 1932) and at Ithaca, New York (Harper, 1921). While these colts were at first smaller than those at Miles City, they finished at about the same size (figures 3 and 4). Comparisons with Crampton's (1923) data from 409 American-bred draft colts furnish similar evidence. Although his colts were larger than the Miles City draft colts, the latter did not maintain the same rleative rate of gain or mature at as large a proportion of their yearling weight, as is shown in figure 3 and in the following tabulation:

Animals	Weights in pounds at different ages					
	Weanling	1 yr.	1½ yrs.	2 yrs.	3 yrs.	4 yrs.
Miles City draft colts (avg. four groups)	604	960	1086	1049	1198	1406
Crampton's colts	730	1020	1350	1480	1790[2]	1980[2]
Relative weights of Miles City colts, in percent of weights of Crampton's colts	83	94	80	71	67	71

[2] Stallions predominated in these classes.

TABLE 3. ANALYSIS OF VARIANCE FOR WEIGHTS AT DIFFERENT AGES[1]

Source of variance	Age									
	Weanlings		1 year		18 months		2 years		4 years	
	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares
Between years within sexes and breed groups	52	11,548**	50	6,590	50	8,768	46	17,053	31	19,789
Between sexes within years and breed groups	28	3,711	26	3,092	26	1,348	23	18,265**	15	14,444**
Between breed groups within years and sexes	44	49,661**	42	146,849**	42	133,926**	38	165,005**	27	218,616**
Within years, sexes and breed groups	237	2,865	223	5,949	208	7,492	197	6,140	90	6,406
Total	396		280		265		250		128	

[1] This table is a condensation of three analyses for each age group. The variances between sex and breed, sex and year, etc., are omitted since they are not pertinent to the study.

** Probability value <.01.

On the basis of Crampton's (1923a) statement that a draft colt receiving proper feed and care should have attained at one year of age 50 percent of his mature weight, the Miles City draft horses should have weighed about twice their yearling weight at maturity or over 1,800 pounds instead of about 1,500 pounds.

The growth curves for weights and heights of the Morgan horses[4] at the United States Morgan Horse Farm at Middlebury, Vermont were much more uniform than those at Miles City (figures 3 and 4). This was because the stock at Middlebury received adequate rations for growth the year

TABLE 4. ANALYSIS OF VARIANCE FOR HEIGHTS AT DIFFERENT AGES[1]

Source of variance	Age									
	Weanlings		1 year		18 months		2 years		4 years	
	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares	d.f.	Mean squares
Between years within sexes and breed groups	52	3.73*	50	4.64**	50	4.16**	46	4.35**	31	2.82
Between sexes within years and breed groups	28	3.25	26	4.95**	26	4.94**	23	29.44**	15	6.68**
Between breed groups within years and sexes	44	9.29	42	16.14**	42	13.57**	38	14.50**	27	11.39**
Within years, sexes and and breed groups	237	2.34	223	2.43	208	2.25	197	2.23	90	1.93
Total	396		280		265		250		128	

[1] See footnote, table 3. * Probability value <.05. ** Probability value <.01.

[4] Unpublished data, Bureau of Animal Industry.

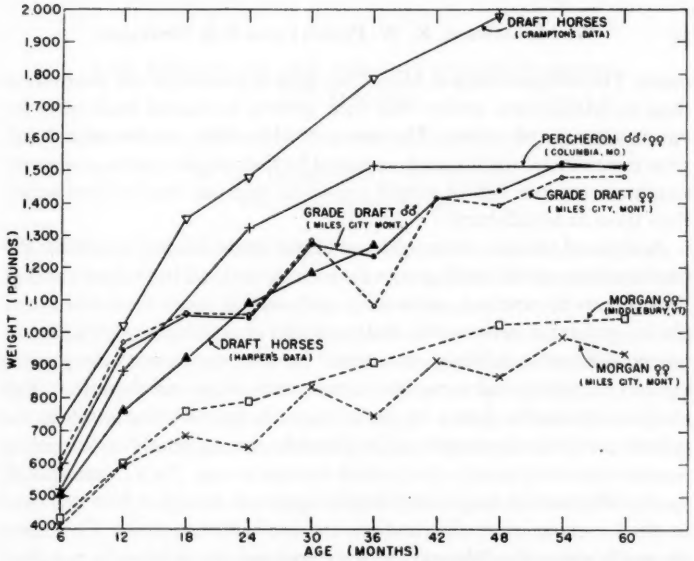

Figure 3. Growth in weight of range-fed horses versus growth in weight of horses fed liberally under farm conditions. (Crampton, 1923; Harper, 1921; Trowbridge and Chittenden, 1932; B.A.I. unpublished data.)

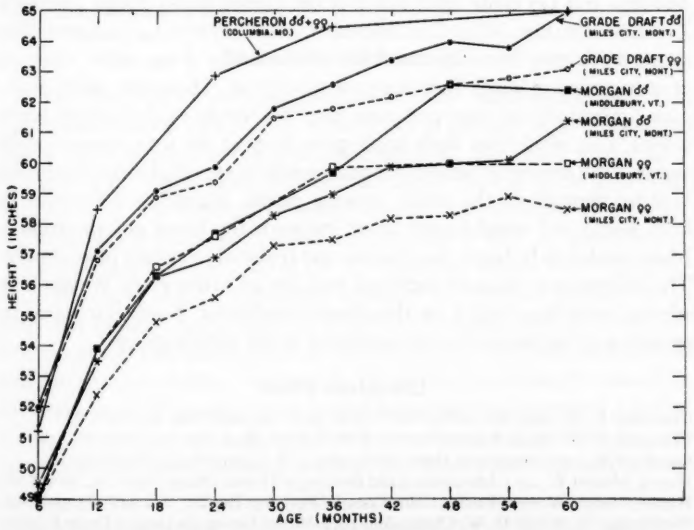

Figure 4. Growth in height of range-fed horses versus growth in height of horses fed liberally under farm conditions. (Trowbridge and Chittenden, 1932; B.A.I., unpublished data.)

round. The Morgan males at Miles City grew at practically the same rate as those at Middlebury, except that their growth fluctuated much more between summer and winter. The mares at Miles City, on the other hand, grew more slowly, and matured, as judged by their size at 5 years, at approximately 100 pounds lighter weight and at an inch and one-half less height than those at Middlebury.

Analysis of variance for weight and height showed highly significant differences between the breed groups for each age studied (see tables 3 and 4). This was to be expected, particularly with weight, since there was a very obvious difference between the draft and light groups (figure 1). Highly significant differences in height were found between the sexes at the yearling age and thereafter, and in weight at two years of age and thereafter. This checks with results shown by the averages in figures 1 and 2, where the growth curves for the weight and height of the sexes generally can be seen to separate more and more as the animals increase in age. For all ages studied, yearly differences in height were highly significant except at four years and in weight, except at yearling and one and one-half years of age. The reason for significant yearly differences at some ages and not at others is not clear.

Summary

Growth studies are reported on 297 horses (16 Belgian, 59 grade draft, 75 Morgans and 147 grade light) foaled at the United States Range Livestock Experiment Station, Miles City, Montana, from 1927 to 1934, inclusive. The young stock grew normally from birth to 18 months of age under a system of management in which they were adequately fed. Thereafter, when maintained principally on range pasturage, they lost weight on the average every winter, and, while they made rapid gains on grass the next summer, they matured at a somewhat smaller size than would be expected if they had been well fed throughout the whole growing period. Significant differences in both height and weight were found between the breed groups studied. Males tended to be larger than females and appeared to mature more slowly. The differences in the sexes increased with age up to five years. Weight was affected more than height by the adverse conditions. Yearly variations in growth were significant but not consistent in the various groups.

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THE EFFECT OF SEX ON THE DEVELOPMENT OF THE PIG

IV. HISTOLOGICAL AND ENDOCRINOLOGICAL STUDIES OF THE BOAR[1]

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THE age at which boars become sexually mature affects the economy of swine production. Late maturity may cause loss owing to litters being farrowed late, necessity of replacing a boar, or changes in a planned breeding program. Sexual maturity may be measured in two ways: (1) the age of first sperm production and (2) the age of appearance of sexual desire. Both sufficient viable sperm and sex drive are necessary for reproduction. Secondary sexual characteristics, "masculinity," are not necessary for successful impregnation but many persons associate these characteristics with reproductive capacity.

In this study, the rate of testicular development was studied with two approaches: (1) the excretion of male hormones and the boars' reaction to them, and (2) the rate of development of the sperm producing elements. Three objectives were in mind: (1) to trace the rate of "normal" development as indicated by the boars used; (2) to find out if the lines differed in their rate of development; and (3) to ascertain whether these differences were correlated with observations of the lines.

Materials and Methods

Lines of inbred swine being developed at the Minnesota Agricultural Experiment Station vary in their fertility, age of puberty in both sexes, and degree of sex interest by the boars (Winters *et al.*, 1942, 1943; Comstock *et al.*, in press). Differences in libido and ability of boars to settle females are not especially characteristics of inbred lines nor unique among inbred lines. Purebred boars of all breeds (inbred and non-inbred) differ in these respects.

All the inbred lines are still in the developmental stages; hence they fluctuate from year to year. Late sexual maturity has appeared in some of the lines that formerly were relatively free from breeding troubles, while difficulties which were experienced in some of the lines have been nearly eliminated in later generations. For example, the Market Lady line, mentioned by Comstock *et al.* (in press), almost passed from existence because of a lack of libido. One boar having high sexual desire was found and used heavily, and the trouble has been almost overcome. The results reported herein were

[1] Paper No. 2157, Scientific Journal Series of the Minnesota Agricultural Experiment Station, University Farm, St. Paul, Minn. This study was conducted with animals produced in cooperation with the Regional Swine Breeding Laboratory, Ames, Iowa, Bureau of Animal Industry, U. S. Department of Agriculture.

based on the status of the lines at the time the data were gathered and the observations made.

For the study of the sperm and male-hormone producing elements, testicles were secured from 78 boars ranging from 8 to 28 weeks of age. At the time of castration, the age, body weight, and testicular weight of the boars were noted. Small pieces of testis were secured from a standard location in the middle of the organ, fixed in Bouin's fluid, sectioned at 5μ, and stained with Heidenhain's iron-hematoxylin. From each testis, 25 circular seminiferous tubules (see Winters, 1939) were selected at random; their diameters were measured and the cell contents classified and counted. Twenty-five more or less circular interstitial cells (of Leydig) were chosen at random and the diameters measured, then the number of these cells occurring in that particular oil immersion field were counted.

For assay of male hormones,[2] the excretion of urinary 17-ketosteroids was studied. The 17-ketosteroids are most likely products of the testes and adrenal glands. If benzene extracts of urine are assayed by a biological method, such as their effect on the growth of capon's combs, a general indication may be secured of the amount of biologically active substances (male hormones) present. Chemical methods of assay measure steroid compounds having a ketone group at the 17th carbon whether they come from the testes or the adrenal. For extracts of boars' urine, the correlation between the capon comb and chemical technics was found to be 0.88 ($P = <0.01$) (Green *et al.*, 1942). Chemical assays, therefore, give a satisfactory indication of the amount of biologically-active male hormones in the urine. These hormones are responsible for the conditioning of the secondary sex glands and for the production of sex drive and secondary sexual characteristics. Extraction and assay methods used for this study were given by Green *et al.* (1942). Data were analyzed according to methods outlined by Snedecor (1940).[3]

Results

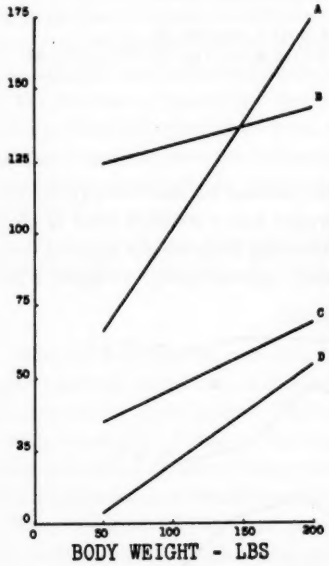
The rate of testicular growth and development was consistently more closely associated with increase in body weight than with the age of the boars, although the difference was not statistically significant. That situation might be expected, because, if the boars grew at a normal rate, there would be a rather high correlation between age and body weight. As sexual development is usually more closely associated with bodily development than age,

[2] In this paper the term "male hormone" will be used to designate 17-ketosteroids although it is not absolutely correct terminology. A total of 486 samples of urine was collected.

[3] For the histological portion, linear, quadratic, and multiple regressions were used to ascertain the types of growth curves of testes and seminiferous tissues and the effect of body weight, age, and testicular size on the rate of growth. Line differences were also determined from the sums of squares of error of estimate of covariance analysis. Comparison of individual group and average regression lines was determined from the sum of squares due to deviation from regression.

one would expect testicular development to follow body weight more closely than age.

The linear regressions of testicular elements concerned in sperm production plotted against body weight are shown in figure 1. The data actually fit curvilinear regression lines better than straight line regressions, but the



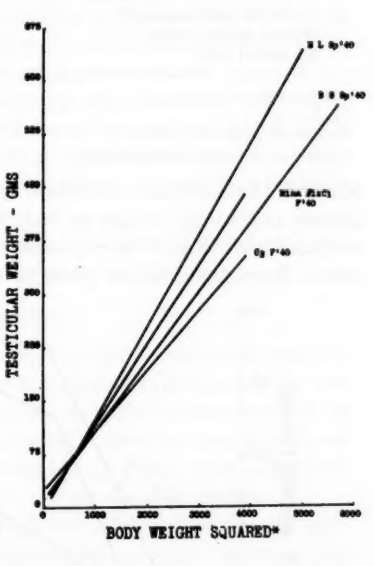


Figure 1 (left). Rate of increase of testicular elements compared with increase in body weight: (A) seminiferous tubular diameter in microns, (B) number of interstitial cells per oil immersion field, (C) number of spermatogonial cells and developing primary spermatocytes per tubular cross section, and (D) number of primary spermatocytes per tubular cross section.

Figure 2 (right). Rate of increase in testicular weight, by groups, compared with the coded square of body weight.* Average regression for all groups was $E=143.8+0.107\,(z-1255)\pm38.7$.

increased accuracy of prediction does not, for practical purposes, warrant the more involved calculation for one wishing to estimate the development quickly. Regression equations are given in table 1.

The regression lines shown in figure 2 indicate the rate of increase in testicular weight plotted against the coded square of body weight, in

* Body weight in pounds squared, divided by 10, and the decimal rounded to a whole number, z.

TABLE 1. REGRESSION EQUATIONS AND STANDARD ERRORS OF ESTIMATE OF TESTICULAR ELEMENTS ON BODY WEIGHT OF BOARS (ALL REGRESSIONS STATISTICALLY HIGHLY SIGNIFICANT)

Spermatogenic element	Regression equation
Seminiferous tubular diameter[1]	$E=92+0.713\ (W^*-86.5)\pm 20$
Spermatogonia and developing primary spermatocytes[2]	$E=43+0.2238\ (W-86.5)\pm 7.3$
Primary spermatocytes[2]	$E=16+0.3366\ (W-86.5)\pm 10$
Interstitial cells[3]	$E=128.87+0.1191\ (W-86.5)\pm 15.88$

* Weight of boar in pounds.
[1] In microns.
[2] Number per tubule cross section.
[3] Number per oil immersion microscopic field.

pounds.[4] The additional calculation was justified because the average regression of testicular weight on body weight had a standard error of 58.7 compared with 38.7 for the regression involving body weight squared (and coded). Regression lines are given for each separate group[5] in figure 2 be-

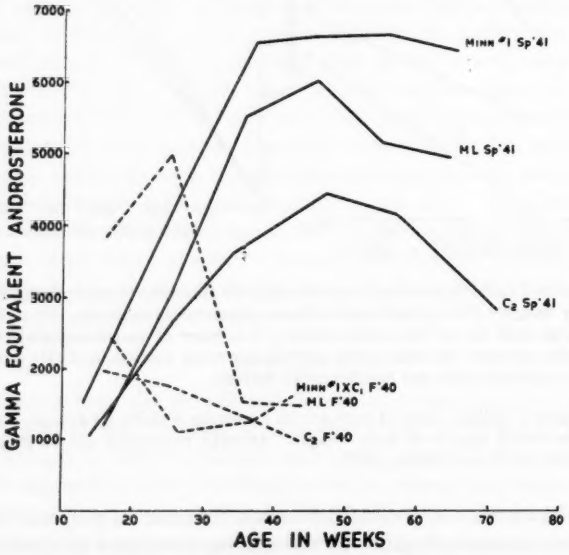


Figure 3. Average amounts of male hormones (17-ketosteroids) excreted by different lines, ages, and seasons of farrow, F = fall farrow; Sp = spring farrow.

[4] The body weight of the boar was squared, divided by 10, and the decimal number rounded to a whole number.
[5] The word "group" was used in place of lines of inbred swine because some lines were sampled from both fall and spring farrowed boars, and one group was the result of crossed lines.

cause the regression lines differ significantly in slope and illustrate the amount of divergence secured in cases of group differences. Other group differences in the rate of testicular development were shown by the fact that the slopes of their regression lines differed significantly in the increase in numbers of (a) spermatogonial cells, (b) primary spermatocytes, and (c) diameter of interstitial cells. Individual group regression lines were not plotted in all cases of significant differences in slope of the lines. Figure 1 depicts, for practical purposes, the rate of development of the various portions of the testes as indicated by the combined data of the boars studied.

The numbers of secondary spermatocytes and spermatids were highly and significantly correlated with the number of preceding cell types, and in increase in tubular diameter. Sperm cells first appeared at ages ranging from 21 weeks in the Minn. No. 1 $\times C_1$ crossbred group to 26 weeks in the Market Lady F '39 group.

The amount of male hormone (17-ketosteroid) excreted varied with age, line of breeding, and season of farrow as shown in figure 3.

Discussion

Differences among the lines have been found in the amount of male hormone excreted, in the rate of increase in testicular weight, and in the rate of seminiferous development. The results show the independence of the production of male hormone, the expression of male hormone in both sex drive and secondary sexual characteristics, and age of first sperm production. This independence is best illustrated by the use of specific examples.

Boars of the Minn. No. 1 line excreted more male hormone than the Market Lady or C_2 boars. They also ranted earlier and more vigorously than the Poland China boars. This earlier development might be the result of many possible causes depending upon the factors initiating and permitting the expression of ranting. (a) If the expression of ranting was simply the result of the production of a certain level of male hormone, the Minn. No. 1 boars would have ranted sooner because they apparently produced more hormones at earlier ages (assuming that higher excretion levels indicated greater production). (b) The lines may differ in the age at which the bodily mechanisms are able to respond to male hormone stimulation. Hooker (1942) has shown that the seminal vesicles of the rat respond to less male hormone at the time of puberty than at pre- or post-pubertal ages. If a similar situation exists for a mechanism such as sex drive, presence of minimal threshold quantities of hormone at a certain age period might induce ranting while larger values might be necessary later. (c) The degree of response may be altered by the external or internal environment of the boars. External environmental causes may be eliminated to quite an extent in this present work

because boars in residence at different substations were managed in similar ways. Boars assayed for male hormone also showed different responses; they were kept in one pen during the experiment. Internal factors may modify the expression of sex drive. Sex hormones alter the metabolism of the body and also cause changes in physical activity. As mentioned earlier, the substances assayed, 17-ketosteroids, may have been gonadal or adrenal in origin. If the higher values recovered indicated differences in adrenal as well as gonadal secretory rates, some of the observed differences in physical activity of the boars may have been induced by differences in adrenal function modifying the expression of sex drive. The thyroid gland is another source of variation in internal environment. If some of these lines were slightly low in thyroid function, that may have accounted for their lowered physical activity, appearance of fatter animals, slower sexual maturity, and reduced or suppressed sex drive.

The independence of the expression of male hormones in the form of sex drive and in masculine appearance of the boars was observed in these lines. The Minn. No. 1 boars did not exhibit as pronounced secondary sexual characteristics, such as heavy shoulder shields, as the Market Lady or C_2 line boars, although the Minn. No. 1 boars ranted earlier and had more libido.

The rate of development of the seminiferous elements of the testes illustrated other interesting differences among the lines. The data indicated that the Poland China lines developed at perhaps an earlier age than the Minn. No. 1 boars and that differences also existed among the Poland China lines in their rates of seminiferous growth. The Market Lady and Black Star boars showed growth curves that were quite different from the C_2 and other Poland China lines. The Minn. No. 1 boars were apparently slower than the other lines in initiating the elaboration of the cell types responsible for sperm production; but growth must have been rapid once it was initiated because these boars produced sufficient sperm by 32–36 weeks of age to yield litters as large or larger than the Poland China lines.

There is no reason why components of sexual development—as shown by early ranting, sex drive, secondary sexual characteristics, or sperm production at an early age—must develop at a similar rate and these lines demonstrate this point clearly. They also raise some pertinent points regarding the selection of boars. The usual method of selecting boars on the basis of masculinity, i.e. well developed secondary sexual characteristics, is not always practical. The Market Lady boars later in life exhibited rather well-developed masculine characters and at a relatively early age apparently had plenty of sperm but in many cases could make little use of them owing to lack of libido. It would be desirable to be able to measure libido by some other method than a direct breeding trial, but at the present time it is impossible to isolate one single cause of sex drive; apparently it is affected by

many factors. The results presented did not answer the problem of how to select boars that would breed females; they apparently did give, however, some indications of a partial answer. While an assay of urinary male hormone excretion would not tell how an individual boar might act, the observed differences in sexual activity of boars *by lines* agreed quite well with the differences in average amount of male hormones excreted *by lines*.

In many species, sex hormones have been found to alter the rate of bodily metabolism and physical activity of the animals. This has been shown by Winters *et al.* (1942) and Comstock *et al.* (1944) also to be true for the lines of swine under consideration. In general, sex hormones (both male and female) were found to affect the growth of sexed animals by an age of 12–16 weeks which was prepubertal in both the Minn No. 1 and Poland China lines. When nearly 16 weeks of age the effects on growth became more pronounced in all lines but especially in the Minn. No. 1 line. Sexually, the Minn. No. 1 boars began to rant and the gilts started to show signs of estrus at approximately 16 weeks of age, while those exhibitions were delayed until 24–30 weeks of age in the Poland China lines. From the study of male hormone excretion, one might conclude that obvious and also subtle changes in bodily metabolism were taking place in both the Poland China lines and the Minn. No. 1 line at similar ages but something prevented as great an expression of these changes in the Poland China lines. On the other hand, it may be indicated that physiological functions other than sex drive may respond to sex hormones differently in the Poland China lines than in the Minn. No. 1 line.

From the above, it seems that selection for sexual maturity at an age early enough to insure satisfactory breeding performance by eight months of age might be incompatible with selection for rapid and/or economical gains, but it is possible to have a line of swine possessing both these traits, as combined in the Minn. No. 1 line. Nevertheless, breeders are not relieved of problems concerned in the selection of individuals. The presence of the gonads alters the rate of growth of individuals, as mentioned above, and as yet there are no methods of testing just how much an animal's rate of gain is affected by the presence of testes or ovaries. Comparison with the gain of a barrow-brother may furnish some indication but as litter mates vary, that is not a completely satisfactory comparison. This study emphasizes the necessity for further work on the problems and the need for refinements in the technics used for the selection of breeding stock.

Summary and Conclusions

1. The sexual development of boars of lines of inbred swine has been studied by the assay of urinary 17-ketosteroids at various ages, and by the measurement of the rate of testicular growth and seminiferous development.

2. Differences among lines were found in the amount of male hormones (17-ketosteroids) excreted in the urine and in the rate of increase in the weight of testes, numbers of spermatogonial cells, and numbers of primary spermatocytes. Differences were also found in the diameters of the interstitial cells.

3. Sexual desire of boars, as a line characteristic, was found to have considerable relationship to the excretion of 17-ketosteroids by the line.

4. The various lines were found to illustrate the independent occurrence of factors usually associated with sexual development: age of appearance of ranting, degree of sex drive, development of secondary sex characteristics, and growth of seminiferous elements. Possible causes of these line differences were discussed.

5. Although it is possible to develop a line of swine which possesses both early sexual development and rapid, economical gains, breeders are still confronted with the problem of selecting individuals and trying to estimate the effects of the gonads on bodily growth and type.

6. When studying problems dealing with sexual maturity in boars, differences in the genetic constitution of the animals, in season of farrow, and in the season of the year in which the data are collected should be considered.

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THE INFLUENCE OF FISH MEAL AND FISH OIL ON THE FLAVOR OF PORK[1]

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A FEW years ago when fish meal was in rather common use in hog rations throughout the country, a fishy flavor in bacon was observed by some meat packers and also by consumers of their product. At that time studies on the effect of fish meals and oils on the flavor of poultry and eggs were being reported by workers in several of the State agricultural experiment stations and in the United States Department of Agriculture.

Mohler (1931) summarized six tests by the U. S. Bureau of Animal Industry on the effect of fish meal on the flavor and aroma of roast pork. Four of these tests were conducted in cooperation with the New Jersey Agricultural Experiment Station. No marked differences were found in the meat from hogs fed fish meal and those receiving tankage. The highest proportion of fish meal in the ration in any case was 10.4 percent, fed from shortly after weaning until the pigs weighed approximately 100 pounds. The fish meal was then reduced to 7.5 percent of the ration and continued until the animals reached a finished weight of approximately 225 pounds. Hostetler (1922), Edwards (1929) and Robison (1932) found no fishy flavor in meat from hogs fed fish meal as supplement to grain.

Fish meal up to 20 percent of mixed protein supplements was included in feeding tests at the Purdue Station from 1937 to 1941. Similar supplements were used by pork producers throughout the State during this period. Because of the trend toward increased use of fish meal in hog rations in this area, a flavor test on meat from hogs fed different amounts of fish meal and fish oil was conducted in cooperation with Kingan and Company of Indianapolis.

Materials and Methods

Four lots of five 67-pound pigs were fed dry-lot rations containing different amounts of menhaden fish meal and menhaden fish oil until they attained an average weight of approximately 218 pounds. The rations are described in table 1. Ration 1 contained 2.5 percent of fish meal, which was slightly more than that found in the complete rations containing the mixed supplements referred to previously. Digester tankage was used in this ration to bring the protein up to a desirable level. Ration 2 contained 10 percent of fish meal which was considered adequate for supplementing the corn ration.

[1] Journal Paper No. 173, Purdue University Agricultural Experiment Station.

Rations 3 and 4 contained sufficient amounts of fish oil in addition to 10 percent of fish meal to make the total fish-oil content 1 and 2 percent respectively.

The rations were hand-fed twice daily and the amount was the same for all lots. The level of feeding was governed by the appetites of the pigs in the lot with the losest rate of consumption. The pigs were fed in each lot for 100 days. The average daily feed per pig was 5.36 pounds, and the feed consumed for one pound of gain was 3.93, 3.93, 3.88, and 3.88 pounds for the four respective lots.

TABLE 1. RATIONS

Ingredients	Lot 1	Lot 2	Lot 3	Lot 4
	percent	*percent*	*percent*	*percent*
Ground yellow corn	88.0	88.0	87.5	86.5
Alfalfa leaf meal	2.0	2.0	2.0	2.0
60% tankage	7.5	—	—	—
Menhaden fish meal	2.5	10.0	10.0	10.0
Menhaden fish oil	—	—	.5	1.5
Total	100.0	100.0	100.0	100.0
Fish oil in ration	.125	.5	1.0	2.0
Fish meal equivalent*	2.5	10.0	20.0	40.0

* Calculated on the fish oil content of the ration and percentage of oil in the fish meal (5%).

Three of the finished hogs from each lot were slaughtered and processed by Kingan and Company for the meat tests. Flavor tests were made on fresh loin roasts and cured bacon from all test hogs by a committee in the Purdue Home Economics laboratory, and on fresh pork chops and cured bacon by several staff members and their families, who received unidentified samples of the meat for cooking and tasting in their homes. Flavor tests also were made on the bacon of all test hogs by a committee at the Kingan and Co. plant. Except for those directly in charge of the tests, committee members were unaware of the source of the pork samples tested for flavor.

Results

Flavor of Fresh Pork Chops

Nine families judged the flavor of the fresh pork chops. The distribution of the chops for tasting tests, by the individual families, was such that a triplicate family test on the chops from each hog was obtained, and each family tasted chops from each lot of hogs. The results of these tests are shown in table 2. Evidence of fishy flavor was found only in chops from hogs fed fish oil in addition to ten percent of fish meal in the ration.

Flavor of Fresh Pork Roasts

A Pork roast from each test hog was cooked in the Home Economics laboratory and judged for aroma and flavor by a committee of ten staff members from the Home Economics, Animal Husbandry, and Agricultural Chemistry departments. The flavor of the lean and fat was judged separately. The results of the flavor tests are shown in table 3. It is evident that fishy and other undesirable flavors were more pronounced in the fat than in the lean tissue of the meat. A marked degree of fishy flavor was found in

TABLE 2. FLAVOR OF PORK CHOPS AS JUDGED BY FAMILIES IN THEIR HOMES

Lot	Chop from hog number	Desirable	Undesirable	Fishy flavor	Number of people judging	Percentage of fish oil in the ration*
1	17	10	—	—	10	0.125
	78	4	4	—	8	
	81	7	1	—	8	
2	76	6	2	—	8	0.5
	84	10	2	—	12	
	85	10	—	—	10	
3	86	5	5	—	10	1.0
	87	7	1	—	8	
	89	6	6	4	12	
4	93		8	5	8	2.0
	94	5	3	1	8	
	95	2	8	1	10	

* Lot 1—2.5% fish meal, Lot 2—10% fish meal, Lot 3—10% fish meal plus .5% fish oil, Lot 4—10% fish meal plus 1.5% fish oil. Menhaden fish meal and oil were used.

the roasts from hogs which received both fish meal and fish oil. The data indicating some fishiness in the fat of roasts from hogs in the other lots are not significant.

The roasts in this test were cooked by the standard method for pork developed by the National Committee on Meat Investigations. Each roast was placed on a rack in an uncovered pan with the fat side of the roast up. The uncovered roast was cooked in an oven preheated to 350° F (and maintained at that temperature) until the temperature of the center of the roast, as indicated by a meat thermometer, was 183° F (84° C).

Flavor of Bacon

Table 4 contains summary data on the flavor of bacon as judged by families in their homes, the Home Economics committee, and the Kingan and Com-

TABLE 3. FLAVOR OF THE LEAN AND FAT OF PORK ROASTS AS JUGDED BY HOME ECONOMICS COMMITTEE

Lot	Roast from hog number	Very desirable		Desirable		Slightly desirable		Undesirable		Fishy flavor		Number of judges	Fish oil in ration, percent
		Lean	Fat	Lean	Fat	Lean	Fat	Lean	Fat	Lean	Fat		
1	17	—	1	5	1	5	4	—	4	—	—	10	0.125
	78	—	—	3	1	7	5	—	4	—	2	10	
	81	1	1	1	—	8	5	—	4	—	1	10	
2	76	1	—	2	1	5	4	2	5	—	—	10	0.5
	84	—	—	2	1	4	4	4	5	—	2	10	
	85	—	—	3	—	6	4	1	6	—	1	10	
3	86	—	—	3	1	5	3	2	6	2	4	10	1.0
	87	—	—	—	—	6	1	4	9	3	6	10	
	89	—	—	—	—	3	—	6	8	5	5	9 & 8	
4	93	—	—	—	—	2	2	8	8	4	7	10	2.0
	94	—	—	1	—	1	—	8	10	5	8	10	
	95	—	—	—	—	2	—	8	10	5	10	10	

pany committee. Fishy flavor was pronounced only in the bacon from the hogs fed fish oil in addition to ten percent of fish meal. This result was similar to that for roasts and chops as shown in the table. The effect of the higher level of fish oil in the ration (lot 4) on the flavor of the bacon is reflected in the decision of the judges who indicated that 61 of the 87 samples judged had a fishy flavor. In contrast with this result, only one sample of bacon out of 87 in lot 1 was judged as fishy flavored and only 5 out of 82 in lot 2, where ten percent of fish meal was fed.

Summary

Four lots of hogs, fed rations containing different amounts of menhaden fish meal and oil, were used to determine the influence of these supplements on the flavor of the pork. The fish meal contained five percent of oil.

Pork chops, loin roasts, and bacon from three hogs of each lot were tested for flavor and desirability by different committees. The results of the tests show that two rations, containing 2.5 percent and 10 percent of menhaden fish meal respectively, produced pork without a distinct fishy flavor. The other two rations, containing 10 percent of menhaden fish meal plus .5 percent and 1.5 percent of menhaden fish oil respectively, produced pork with considerable fishiness of flavor.

The roasts and bacon from the lot receiving 1.5 percent of fish oil in addition to 10 percent of fish meal were decidedly fishy in flavor. This ration also

TABLE 4. SUMMARY OF TESTS FOR FLAVOR OF PORK

Lot	Hog number	Chops		Roasts			Bacon		Fish oil* in ration, percent
		Number of judges	Number reporting fishy flavor	Number of judges	Number reporting fishy flavor		Number of judges	Number reporting fishy flavor	
					Lean	Fat			
1	17	10	0	10	0	0	27	0	0.125
	78	8	0	10	0	2	32	0	
	81	8	0	10	0	1	28	1	
2	76	8	0	10	0	0	28	3	0.5
	84	12	0	10	0	2	25	2	
	85	10	0	10	0	1	29	0	
3	86	10	0	10	2	4	31	8	1.
	87	8	0	10	3	6	25	6	
	89	12	4	9 & 8	5	5	27	10	
4	93	8	5	10	4	7	29	24	2.0
	94	8	1	10	5	8	30	18	
	95	10	1	10	5	10	28	19	

* Lot 1—2.5% fish meal, Lot 2—10% fish meal, Lot 3—10% fish meal plus .5% fish oil, Lot 4—10% fish meal plus 1.5% fish oil. Menhaden fish meal and oil were used.

produced some fishiness in the chops. Less of the fishy flavor was found in the meat from the lot receiving the .5 percent additional fish oil. Fishiness was more pronounced in the roasts and bacon than in the chops.

Some undesirable flavors, other than fishiness, were found in some of the roasts and chops from all lots. These flavors occurred in both the fat and lean meat, but like fishiness, were more pronounced in the fat.

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THE USE OF SILICA AS A REFERENCE SUBSTANCE IN DIGESTION TRIALS WITH RUMINANTS.

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A SIMPLIFICATION of the usual methods employed in digestion trials makes use of naturally occurring silica in feed as an unabsorbable reference material to calculate the digestibility of other feed constituents. The percentage change in the nutrient: silica ratio of the feed in passing through the digestive tract gives an indirect measure of the apparent digestibility of the corresponding nutrient. The reliability of digestion coefficients computed in this manner depends primarily on the uniform distribution of silica in the feed and its elimination in like manner with practical completeness in the feces. Under these conditions the quantitative collection of feces is not necessary although, to insure representative sampling, it may be desirable to collect random samples at frequent intervals (Gallup and Kuhlman, 1936). Mitchell (1942) in a discussion of the literature on the subject points out that the method might be applied to animals on pasture providing samples of feces could be secured without contamination. Recently it became convenient to examine this method under varied conditions when applied to large animals on practical rations. Particular attention was given to the quantitative recovery of silica in the feces.

Experimental

Representative samples of feed and aliquots of the total feces collected from steers and sheep on digestion trials were secured for proximate analysis and silica determinations. The manner in which the trials were conducted varied in several respects. In some trials the steers were stanchioned on raised wood floors in a barn. The feces were caught in a wooden trough and transferred at frequent intervals during the day to galvanized iron containers having tight-fitting lids. Urine was collected separately by means of rubber funnels and hose that led to containers beneath the floor. In other trials the steers were kept outdoors in pens and fed individually or allowed on pasture where they grazed native grass. Canvas sacks harnessed to the steer were used for the quantitative collection of feces in these outdoor trials. The sacks were changed twice daily. In all trials with the sheep, the animals were kept on false floors in metabolism crates of the usual type in a small shed.

The rations were fed in weighed amounts twice daily. They consisted of

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native grass, alone, and supplemented with cottonseed meal; prairie hay, alone, and supplemented with cottonseed, soybean, and peanut meals, singly and in combination; and silage supplemented with various amounts of cottonseed meal, soybean meal, and oats.

Corrections for uneaten residues were negligible in all trials except those in which either prairie hay or native grass was fed without a supplement. The grass intake of individual steers on pasture was calculated from the amount of dry matter defecated, the dry matter consumption: defecation ratio being determined for each steer during an adjacent dry-lot period when known amounts of the grass were fed. (Garrigus and Rusk, 1939)

Preliminary feeding periods of 10 days duration or longer were followed by collection periods of 8 or 10 days duration. The feces collected daily from each steer were weighed, and after thorough mixing aliquots were preserved with thymol in glass jars in an electric refrigerator. At the close of each trial the aliquots were mixed and representative samples dried for analysis. The total feces collected from each lamb were preserved by drying and representative samples of these total collections were taken for analysis at the close of each trial.

The composition and silica content of the native grass fed were determined on composite samples of daily cuttings. Analysis of prairie hay and all concentrate feeds was made on representative portions secured at the beginning of the trials in which they were used. During several trials the hay and concentrates were sampled daily as a check on possible changes in composition. When silage was fed, daily samples taken at feeding time were combined for analysis.

Results

The amounts of silica, expressed as percentages of the intakes, that were recovered from the feces of steers and sheep when the various rations were fed under different experimental conditions, are shown in table 1.

In all but one series of trials, the average amount of silica recovered from the feces was greater than the amount in the feed consumed. When the steers were stanchioned inside and the feces collected regularly throughout the day by an attendant, silica recovery in 8 trials averaged 103 percent and in 18 trials, 94.5 percent of the intake. Digestion coefficients computed from the nutrient: silica ratios of the feed and feces in these trials would be within the range of the values secured by the usual method of calculation. When the steers were individually fed in outdoor pens and the feces collected in sacks, the average silica recovery varied from 107 to 112.5 percent of the intake. Thirty-two trials were conducted in this manner. Digestion coefficients calculated from these values would be slightly higher than those calculated

by the usual method since a 10-percent error in silica determinations would produce an error of about 5, 2.5, and 1 percentage units in coefficients of 50, 75, and 90, respectively.

The highest values for silica recovery were obtained when the steers were on pasture. These high values, which averaged 136.3 percent, suggest a possible error in the procedure employed to calculate the dry matter and silica intake of the animals. However, values for the digestibility of crude fiber

TABLE 1. THE PERCENTAGE RECOVERY OF INGESTED SILICA FROM THE FECES OF STEERS AND SHEEP IN DIGESTION TRIALS CONDUCTED UNDER VARIOUS CONDITIONS

Animals and experimental conditions	Number of trials	Roughages fed	Concentrates fed[1]	Average silica content of ration	Average recovery[2]	Standare deviation	Standard error of means
				Percent	*Percent*	±	±
Steers in stanchions	8	prairie hay	none	6.18	103.0	7.06	2.50
Steers in stanchions	18	prairie hay	oil meals	5.63	94.5	3.65	0.85
Steers in dry lot	9	native grass	none	6.38	107.0	6.17	2.06
Steers in dry lot	8	native grass	cottonseed meal	6.24	112.5	5.01	1.77
Steers in dry lot	15	silage	oil meals; grain	3.76	112.1	8.78	2.27
Steers on pasture[3]	8	native grass	none	6.37	136.3	16.90	5.98
Sheep in metabolism crates	8	prairie hay	none	4.76	111.6	6.23	2.22
Sheep in metabolism crates	32	prairie hay	oil meals	4.33	105.6	5.23	0.95

[1] The oil meals were cottonseed, soybean and peanut meals; the grain was barley and oats.

[2] Expressed as a percentage of the intake.

[3] Feed intake estimated from dry matter consumption: defecation ratios determined during adjacent periods when the steers were in dry lot.

based on these feed intakes were found to be in close agreement with those obtained when known amounts of grass of similar composition were fed in ordinary trials. Since there was no opportunity for the feces to be contaminated with silica during collection periods, it seems probable that the animals in grazing consumed appreciable amounts of silica in the form of dirt.

In the trials with sheep, the feces were collected on screen trays directly beneath the false floors of the metabolism crates. The silica recovery values, which averaged 111.6 percent in 8 trials and 105.6 percent in 32 trials, indicated silica contamination. The source of the extra silica could not be determined; presumably contamination occurred during the 24-hour periods

of collection when the feces were exposed to barn conditions. It was noted, however, that the silica content of the feces from individual lambs varied only slightly and that high recoveries were associated with high dry-matter output.

Summary

The percentage recovery of ingested silica was used to test the applicability of the silica-ratio procedure to digestion trials carried out under different experimental conditions with large animals on practical rations. The trials were conducted with steers in stanchions, in dry lot, and on pasture, and with sheep in metabolism crates of the usual type.

Dry matter and silica intake of the steers on pasture was calculated from the dry matter consumption:defecation ratios established for each steer during adjacent feeding periods. Feed intake during all other trials was determined in the usual manner.

The recovery of ingested silica was practically quantitative when the steers were in stanchions and the feces collected semimanually. When the steers were in dry lot and the feces collected in canvas sacks, the average excretion of fecal-silica exceeded the calculated intake by about 10 percent. When the steers were on pasture, fecal-silica excretion was 36 percent higher than the calculated intake, due presumably to dirt ingested by the animals in grazing. In the trials with sheep, fecal-silica averaged 107 percent of the calculated intake. Contamination apparently occurred when the feces were exposed to barn conditions during the day of collections.

In general the results indicate that under favorable conditions the silica-ratio procedure is adaptable to digestion studies with steers and sheep. Digestion coefficients so computed, where silica errors are 10 percent or less closely approximate those obtained in ordinary trials. Precautions, other than those usually observed in digestion trials, are necessary however, to keep silica contamination at a minimum. High results may be expected in trials conducted with animals on pasture.

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RECORD OF PROCEEDINGS OF THIRTY-SEVENTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

THE meetings were held at the Hotel Morrison in Chicago, on December 1 and 2, 1944, and a luncheon for the honor guest was held at the Stockyard Inn on December 3.

The scientific papers presented in the sectional meetings were published in abstract form in the JOURNAL OF ANIMAL SCIENCE, Volume 3, No. 4, pages 431–456. The president's address, a resume of the business was conducted by the Society, and other items of interest to the membership are presented in the following pages.

PRESIDENT'S ADDRESS[1]

L. A. WEAVER
University of Missouri

THIS is the 37th annual meeting of the American Society of Animal Production. It seems logical to assume that any organization of this type, which has had a steady growth in membership and activities over so long a period, has served well its membership and the industry represented.

The desirability of having constructive breeders, outstanding feeders, and other leaders in the production field represented in the membership list has been recognized. From time to time ways and means of bringing this about have been discussed. To date however, membership of the Society has consisted mainly of workers in the fields of research, college teaching, or livestock extension.

Even with this limited classification, there is a rather wide range of interests among the membership. If, therefore, the organization is to maintain the interest and support of these different groups, there is need for greater coordination of effort to the end that the particular activities of each group will contribute to a well balanced program of the whole. Only in this way can the Society expect to adequately represent and serve the entire industry.

In the addresses of former presidents of this Society ample evidence is found to indicate that one of the concerns of earlier times was for improvement in methods of research including more careful selection, planning, and execution of projects.

The annual proceedings in which these addresses were published not only show a substantial increase in quantity of work accomplished over the years but also striking, almost unbelievable, progress in quality of research

[1] Presented at the opening session of the 37th annual meetings of the American Society of Animal Production.

reported. This improvement, in part the result of the constructive work of the standing committee on investigation and the stimulating effect of its recommendations upon individual members, has more than justified the existence of the Society.

During these earlier periods workers had more or less direct contact with producers so that the nature of projects, interpretation and reporting of results and application to the farm enterprise was a relatively simple matter. However even in those days a word of caution regarding reports was occasionally included in the President's address. In 1933, for example, Professor George C. Humphrey stated that "too much literature is difficult to read and interpret and it is not surprising to hear criticism of experiment station work."

In recent years there has been a marked increase in number of workers, many of whom have relatively little opportunity for close contact with actual production. Workers have also become more specialized. Instead of an individual being responsible for securing the information and for its dissemination to college students and farmers we now to a much greater extent have these responsibilities divided.

Keeping in mind also that interpretations and applications have become much more complicated because of improvements in methods of approach, techniques, etc. a much greater effort must now be made to interpret and report research results so they will be usable by farmers and stockmen and those who serve them in an educational capacity.

It is recognized that as a group the membership of this Society consists of experienced and well trained persons in the various fields represented. It is my opinion however that many members of this Society fail to make full use of some important research, since, either because of lack of time or inadequate special training, they are unable to understand the reports.

This does not imply that research should be less thoroughly planned or executed. In fact we can expect experimental procedure to continue to become more rather than less complicated and technical. If statistical analyses are required they must be made, but surely the results can be reported so as to be usable by the producer the research was planned to help or at least by the well trained educational workers who are in constant and direct contact with producers. This should be true even though the producer or extension worker does not possess the mathematical knowledge needed by the research worker and used by him to such good advantage as a research tool.

This group has a very definite appreciation of the relation of research to progress of the industry and how this may influence world affairs. Results of research can be of service however only when used. More careful thought should therefore be given to the use which can be made of the results secured

by constantly improved methods of experimentation so that reports, interpretation, and application will be made as simple and understandable as possible. This organization can, by accepting responsibility for leadership in this connection, make another substantial contribution to Society.

It must be remembered too that during the post war period competition may be keen for public monies and unless a satisfactory relationship exists between research workers and practical producers the necessary support for securing needed funds for experimental research may be lacking. While always an important consideration, this point, because of the changed conditions outlined and predicted, calls for careful thought by those interested in securing or using public funds for research purposes.

It is obvious that during the post war period the Society will have increased opportunities and responsibilities regarding the teaching of Animal Husbandry. All appreciate the necessity of proper training for the men who will be the future workers in all of the fields represented by our membership.

Since agriculture, and specifically Animal Husbandry, is an art as well as a science, this Society can be of maximum service to the industry only if it takes cognizance of this fact. If this is not done the influence and usefulness of future workers in the livestock field may be distinctly limited as compared with that of many earlier leaders such as Henry, Curtiss, Davenport, Plumb, True, and the Mumfords, to mention only a few.

It would seem imperative then that recognition be given not only to the need for well trained and efficient research workers but, if we are to have a well balanced program, also for well trained and efficient workers in every phase of livestock endeavor. If proper facilities for securing this training and experience are not available then they should be provided.

I believe this has not been sufficiently well done in the development of Agricultural Education with the result that, as compared with scientific phases, equal opportunity has not been provided for teachers in Animal Husbandry and those interested in the art of the profession to secure the benefits of more formal training which would be indicated by suitable advanced degrees.

A few years ago this was given some consideration by the Society but unfortunately was not carried to a definite conclusion. I believe a real contribution might be made to Agricultural Education if this organization would give further careful thought to this matter and make recommendations regarding graduate curricula which would overcome existing inadequacies.

The need for revision of undergraduate curricula is evidenced by the fact that most institutions are now or have recently been considering changes. The Society should, as in the past, contribute not only to the estab-

lishment of successful undergraduate curricula but also in making effective better methods of teaching.

As a part of a well balanced educational program which is so important in the over all picture, the extension worker has become a real asset to Society. During the present emergency he has perhaps contributed more directly to the war effort than any other group of our membership.

The extension worker is privileged to have that direct contact on the firing line which is of such great value in providing proper perspective as to need for new information and evaluation of research results. This privilege carries with it important responsibilities such as keeping in touch with results of current research and providing research workers with information relative to research needs.

Stated simply, the extension worker can make a real contribution by suggesting problems needing solution. The research worker can by careful planning, execution, and reporting provide the answer. The extension worker helps the producer make the proper application, thus increasing confidence in and use of animal research. In this way the necessary support is secured.

Greater coordination of effort, then, particularly between research and extension workers, becomes not only desirable but necessary.

The livestock industry will not only profit from better coordination of effort between our members but there is need of more concerted action on the part of this Society and related organizations. Much progress has recently been made in this direction but ways of increasing cooperation should be considered.

The following are a few points which the Society, through its committees and individual members, might wish to consider. 1. Expansion of membership to include leaders in animal husbandry fields other than research, teaching and extension. 2. Greater coordination of activities of groups represented in the membership. 3. Securing a wider range of articles for the JOURNAL OF ANIMAL SCIENCE, with a simplification of reports so as to appeal to and be useable by a larger number of people. 4. Outline undergraduate and graduate curricula to provide adequate training and give suitable and equal recognition to men who will be future leaders in all phases of the industry. 5. Securing greater Society activity of a sectional nature—increasing the number or redistricting sections if this appears desirable from standpoint of workability. 6. Ways to bring about increased cooperation between this and related Societies.

In closing I want to express my appreciation of the honor and privilege I have had in serving as your President. I am grateful for the fine cooperation and help which members and officers have given. In some ways this has

been a critical time for the Society. The post war period, which God grant may start soon, will no doubt offer new and increased responsibilities and opportunities for our organization. May we be prepared to render full service at that time.

SUMMARY OF THE MINUTES OF THIRTY-SEVENTH ANNUAL BUSINESS MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

W. V. LAMBERT, *Secretary*
Purdue University

THE meeting was called to order by President L. A. Weaver at 2:00 P.M., December 2, 1944, in the Morrison Hotel, Chicago, Illinois.

The Treasurer's report showed a balance on October 1, 1944 of $6,003.50, which represented an increase of $781.30 over the balance reported a year earlier. A special auditing committee, consisting of M. L. Baker and C. E. Terrill, reported that they had examined the accounts of the Treasurer and found them in order.

The Committee on Investigation called attention to the fact that certain coordinating bodies had been formed recently. These included an Inter-Association Council representing the animal production, dairy, poultry, veterinary science, and livestock sanitary groups, and a Board of Agriculture under the Division of Biology and Agriculture of the National Research Council. Basic research in the field of animal production involves many branches of science, and the Committee pointed out the importance of close coordination of activity among various subject-matter departments and among institutions. It was recommended that the Executive Committee consider giving opportunity for a discussion group at the next annual meeting for consideration of problems that might lead to desirable cooperative research and might be dealt with through the coordinating agencies mentioned above. The following topics were suggested:

1. Some of the broader aspects of animal-plant relationships, particularly those relating to range livestock management.
2. Breeding of animals for adaptation to various environments. An enormous amount of work has been done on problems of modifying environments to suit the inherent characteristics of animals, but comparatively little conscious effort has been made, particularly with beef cattle, in breeding animals to suit the environment.
3. Studies of breeding sheep for improvement of economic characters.
4. Studies of breeding beef cattle for improvement of economic characters.
5. Nutrition of young animals.
6. Studies on maternal nutrition.
7. Milk secretion in meat animals.

8. Cooperative research to fill in the gaps in knowledge brought to light by the committees working on recommended nutritive allowances for various species of livestock.

The Committee on Information reported that 32 papers which appeared to be of most general interest had been selected for publicizing in livestock, farm and market publications. The news stories based on these reports, and other items of interest concerning the society meeting, were mailed to 102 papers in all sections of the country and to radio and news agencies in Chicago. It was reported that similar material mailed out concerning last year's meetings was used by at least 40 publications.

The following tabulation was given by the Committee on Membership:

Paid membership, 1944	521
Unpaid memberships, one or more years	59
New members, 1944	112
Foreign members, 1944	17
Subscribers (individuals and corporations in the United States)	67
Subscribers United States Libraries	75
Foreign Libraries	58

The Committees on Instruction, Extension and Meat Investigations did not make reports.

The Committee on Pasture and Range Investigations recommended continued emphasis on State and regional programs dealing with forage production and utilization. It also suggested that, in view of recent research on dressing percentages, nutritive value, palatability, and tenderness, federal graders and cattle buyers cease discrimination against grass-fattened beef on the basis of color of fat alone.

The Committee on Evaluation of Feeds pointed out that the long-used system of proximate analysis, including, besides water, five fractions, no one of which is either a chemical or biological unit, must be replaced as soon as possible with a more precise scheme. It pointed out that few laboratories are equipped to determine more than a very few of the substances already known to be of nutritional significance, but that many laboratories have developed facilities for routine chemical examination of feeds for one or more specific nutrients, such as amino acids, vitamins or inorganic elements. It suggested a plan whereby several cooperating laboratories would make those determinations for which they were equipped and for which a central coordinating organization would compile the results obtained. It was emphasized that additional funds would be required for it is unlikely that State or commercial laboratories could take on the responsibility of extra analytical work. A piece-work plan of payment was suggested. The following items were tentatively proposed for inclusion in the list of data to be obtained:

Non-Chemical: Common and other used names, date and place of original sample, date of origin if different from sampling date, processing procedure including heat

or water treatments, physical condition as size of particles, recognized market grade if applicable, degree of purity as in grains.

Chemical: Moisture, total nitrogen, ten essential amino acids, total fatty acids, iodine no., saponification no., cellulose, hemicellulose, starches and sugars, lignin, vitamins A, D, E, thiamin, riboflavin, pyrodoxine, pantothenic acid, calcium, phosphorus, common salt, iron, iodine, manganese, selenium, fluorine.

Biological: Where possible it would seem that such data as digestibility coefficients where applicable, biological values and metabolizable energy values should be included.

The lack of a central coordinating agency was pointed out, and it was suggested that the Committee on Animal Nutrition of the National Research Council might function in this capacity. It was recommended that the general plan be considered by the Society with the view of endorsing and submitting it to the National Research Council for consideration. It was also proposed that arrangements be made with the dairy and poultry science associations to determine if they wished to support the proposed plan.

The Committee on Registration of Animals Produced by Artificial Insemination reported that the problem had been considered, and that it had consulted closely with a representative of the American Dairy Science Association in the study of the problem. The essential procedure for registration of animals produced from artificial insemination was suggested as a guide for breed associations.

(1) When a breeder on his own premises conducts or supervises collection of semen from his own male animal for the insemination of his own females, no official forms are required for registration of offspring.

(2) When a male is owned by one breeder and the semen is carried or shipped to inseminate a female owned by another breeder, a special form is required for reporting the insemination.

(3) In approved cooperative artificial breeding associations the secretary or other executive may apply to the breed record association for permission to practice artificial insemination in the purebred herds of its members. Such artificial breeding associations should meet certain requirements and be approved by a representative of the State agricultural college or extension service. Technicians employed by such associations should also be approved by the same authority.

The experience with dairy cattle has demonstrated that registration of animals born of artificial insemination is somewhat more expensive than of those produced by natural service. The Committee felt that an extra charge for registration of animals born of artificial insemination would be undesirable and suggested that a license fee of $5.00 to $25.00 annually for each male animal so used might be considered as an alternative. The Committee considered that its work was finished and requested that it be dismissed.

The following officers were elected for 1945:

President: A. D. Weber

Vice-President: W. A. Craft

The Committee on Resolutions presented the following resolutions which were adopted:

1. That thanks be extended to the management of the Morrison Hotel, for the facilities, accommodations and courtesies provided under difficult circumstances.

2. That due thanks and appreciation be extended to the officers of the Society for their fine work through the past year and to the speakers and guests and all others who have contributed to the various programs of the annual meeting.

3. That thanks and appreciation be extended to the Committee on Information and to the National Livestock and Meat Board for the excellent services rendered by Mr. Biggar.

4. That for future meetings an attempt be made to secure papers on the subject of livestock marketing for inclusion in the program of the appropriate subject matter sections.

5. That the Executive Committee, through appropriate sub-committees of the Society, explore the advisability of holding group conferences of workers in specific fields, probably on a regional basis, to better coordinate the work being done in such fields.

6. That members from all branches of the Society, research, teaching and extension, be urged to submit papers to the JOURNAL OF ANIMAL SCIENCE in order that the JOURNAL may more adequately cover the entire field in which the Society is active.

W. V. Lambert, the Society's representative on the Inter-Association Council, presented the following report:

Progress was made during the past year on publication of the live stock programs which were undertaken as one of the first activities of the Council. A war production program on sheep was published in the March, 1944 issue of the Journal of the American Veterinary Medical Association. The Council arranged with the officers of the National Livestock Conservation Program to publish two circulars dealing with the raising of sheep, one concerned with farm flock management and the other with range flock management. Another program dealing with dairy goats was prepared by this same committee, and accepted by the American Goat Association for publication in their year book and by the Goat World. The sub-committee in charge of the preparation of these reports consisted of Professors I. B. Boughton, Chairman, O. C. Cunningham, F. S. Hultz, F. H. Leinbach, and R. F. Miller. A manuscript dealing with swine production is in course of preparation for publication as a leaflet by the National Livestock Conservation Program. Progress has also been made on a manuscript dealing with dairy production and this will soon be ready for publication.

At the meeting of the Council in December, 1943, the Committee on Nutrition of the American Veterinary Medical Association discussed with the Council the possibility of using the information on nutrition as contained in the various livestock programs mentioned above. It was considered that these might be of interest to many members of the veterinary profession. The Council has offered to obtain the help of outstanding nutrition workers for the preparation of such articles.

In August 1943, representatives of the Council attended, by invitation, a meeting of the Committee on Animal Health of the National Research Council. The Committee on Animal Health was advised of the discussion by the Council, regarding the resolution requesting a study of the vaccination of adult cattle against brucellosis, which was presented by the American Dairy Science Association at their annual meeting in June, 1943. The Council requested that the committee on Animal Health of the National Research Council make such a study. Its report was presented in the October, 1944 number of the Journal of the American Veterinary Medical Association.

Following their meeting in June, 1943, the Council undertook the preparation of a program

for 'Protecting and Promoting the Welfare of the Livestock Industry." It is expected that these proposals, if they are approved by the member associations, will be published. It is hoped they will stimulate greater efforts for inprovement of the industry by all agencies concerned. It is understood that such approval has been obtained from all associations except the U. S. Livestock Sanitary Association which will consider the program at its coming meeting.

In ccordance with the resolution passed at the 1943 annual meeting of the American Society of Animal Production, a letter was prepared by the Council pointing out the critical man-power situation in the livestock field. This letter was sent to Paul V. McNutt, General Lewis Hershey, Claude R. Wickard and Marvin Jones.

The Special Committee on Registration of Animals Produced by Artificial Insemination and the Recognition of New Breeds referred their report of December, 1943 to the Council for consideration and possible further action. The matter is under study by the Council.

In August, 1944 the Council met with the Committee on Animal Health of the National Research Council to discuss problems relating to coordination of efforts of the various animal science associations, as well as correlation of the work of the Inter-Association Council with that of the Committee on Animal Health of the National Research Council. A resolution from the American Dairy Science Association was presented to the Inter-Association Council, asking that a study be made of the question of obtaining greater uniformity between the states on the problem of calfhood vaccination. This is now under consideration by the Council.

Contributions from the member associations to help defray needed expenses have been received as follows: Americau Society of Animal Production—$25.78, American Veterinary Medical Association—$97.04, Poultry Science Association—$25.20, United States Livestock Sanitary Association—$25.00. Total—$173.02. It is understood that approval for a contribution has been given by the American Dairy Science Association.

Owing to ill health and the pressure of other duties, Dr. H. W. Jakeman resigned from the Council early in 1944. Dr. O. V. Brumley and Dr. W. E. Peterson have been appointed as representatives from the American Medical Association and American Dairy Science Association, respectively.

The report of the Editorial Board included a statement that 156 papers had been submitted up to November 15, 1944. Of these 127 had been published in the first three volumes of the JOURNAL OF ANIMAL SCIENCE; eleven were in press for the February, 1945 issue; seven were being edited; and 11 had been refused or withdrawn. Abstracts of papers presented at the annual meetings had been published as follows: 1941—80 abstracts; 1942—52 abstracts; 1943—60 abstracts; 1944—72 abstracts. It was emphasized that every effort had been made to maintain high standards in the material published, in line with the idea that the main function of the JOURNAL is to make new and worthwhile information available to the members of the Society. Editorial comments and criticisms are supplied to authors to assist them in presenting their material in the best possible form. Papers not suitable for publication have been rejected. In the editing of manuscripts, most authors have cooperated wholeheartedly, and in the final analysis the success of the JOURNAL rests with the membership. Regardless of the effort expended by the Editor and the Editorial Board, *the type and quality of material published is determined largely by the members who prepare papers.*

R. S. Glasscock and P. B. Pearson were selected, respectively, as meats and nutrition representatives on the Editorial Board and will replace W. J. Loeffel and W. E. Krauss on January 1, 1945.

A vote of thanks was extended to the retiring President and other officers of the Society for their efforts during the past year.

The meeting adjourned at 4:00 P.M.

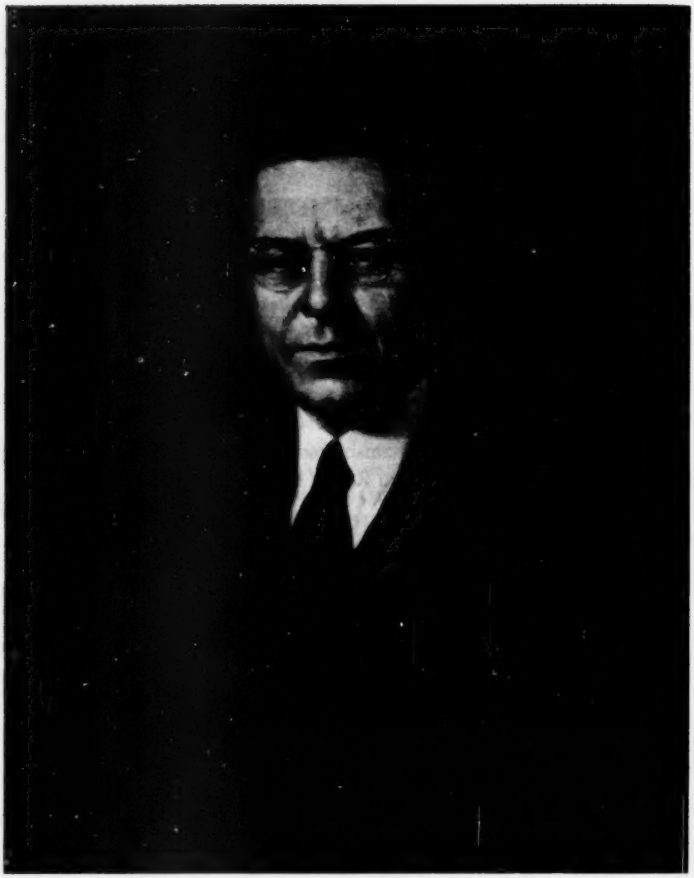
CHAIRMEN OF COMMITTEES FOR 1945

Committee on Investigation.....L. M. Winters (Minnesota)
Committee on Instruction.....R. F. Cox (Kansas)
Committee on Extension.....L. A. Richardson (Tennessee)
Committee on Membership.....W. A. Craft (U.S.D.A., Ames, Iowa)
Special Committee on Information.....
R. C. Pollock, (Nat'l Livestock and Meat Board, Chicago)
Special Committee on Cooperative Meat Investigations.....
J. M. Ramsbottom (Swift and Company, Chicago)
Special Committee on Pasture and Range Investigations.....
M. L. Baker (Nebraska)
Special Committee on Evaluation of Feeds.....
E. W. Crampton (Macdonald College, Quebec)
Special Committee on Necrology.....W. E. Carroll (Illinois)
Representative on the Inter-Association Council..W. V. Lambert (Indiana)
Representative on National Research Council..H. W. Marston (U.S.D.A.)

MEMORIAL

T. M. OLSON

Professor T. M. Olson, Head of the South Dakota State College Dairy Department and Dairy Husbandman for the South Dakota Agricultural Experiment Station for the past twenty years, died suddenly at his home in Brookings, South Dakota, October 24, of a heart attack. Professor Olson was 60 years old. He had been a member of the State College faculty for 24 years. He was the author of many scientific articles and bulletins and one textbook, "Elements of Dairying," now a standard text in agricultural schools throughout the nation. A graduate of the University of Wisconsin in 1915, Prof. Olson later obtained the Master of Science degree in Dairying from Iowa State College, and continued advanced study at both the University of Wisconsin and the University of Minnesota. He was active in promoting dairying and dairy manufacturing in South Dakota, and for many years served as secretary of the South Dakota State Dairy Association, an office he held at the time of his death. Prof. Olson was a member of Gamma Sigma Delta, Alpha Zeta and Lambda Gamma Delta, honorary scholastic societies, and of the American Society of Animal Production and the American Dairy Science Association.



Frank G. King

Reproduction of a portrait presented to the Saddle and Sirloin Club in Chicago by the American Society of Animal Production on December 3, 1944. Frank G. King was the Honor Guest of the Society during its annual meetings which were being held at that time.

FRANK G. KING

Honor Guest—1944

Frank G. King was born December 18, 1884, on a farm near Sweet Springs, Missouri. His early life was devoted to general farming and associated with the King family. They purchased and fed beef cattle, hogs, and mules.

In the fall of 1904 Frank G. King entered the University of Missouri and received his Bachelor of Science in Agriculture degree in 1907. After completing his work at Missouri, he became assistant to Dean Henry J. Waters, who was doing extensive research work in cattle feeding and growth studies with young cattle.

One year later, in 1908, King joined the staff of the Missouri State Board of Agriculture. During that year he devoted himself to extension work in livestock production. Much of the time was spent traveling about the state of Missouri and attending various types of meetings devoted to the discussion of livestock problems.

In 1909, Frank G. King joined the Animal Husbandry staff at Kansas State Agricultural College, Manhattan, Kansas. At this institution he devoted his time to teaching and helping with research programs. In the fall of 1910 he was employed by the Animal Husbandry Department at Purdue University to devote his entire time to research in livestock feeding. In the immediate years that followed Professor King expanded the cattle feeding work, started sheep feeding, and conducted phases of work with feeding hogs.

In May, 1917, he entered the armed service of his country and was commissioned a captain in the 325th Field Artillery in August of that year. Six months were spent with the American Expeditionary Forces overseas. He returned to the Animal Husbandry Department in March 1919.

In the fall of 1928 Frank G. King was appointed head of the Animal Husbandry Department of Purdue University, succeeding the late Dean J. H. Skinner, who a short time previously had assumed the responsibilities of Dean of Agriculture and Director of the Agricultural Experiment Station and Extension Service. Professor King has continued his activities in cattle feeding through the years and has spent much time in supervising the breeding, feeding, and management of the herds and flocks on the Purdue University Farm. Since becoming head of the Animal Husbandry Department, he has taught an advanced course in livestock production to Animal Husbandry students.

Professor King has taken an active part in community affairs, especially the Christian Church. He is a 32nd degree Mason and a member of the Elk lodge.

NEWS AND NOTES

Notices of change of address should reach the Secretary of the Society at least 40 days in advance of the month of publication of the issue for which they become effective. Members and subscribers will relieve the Secretary of considerable trouble and work by supplying new addresses well in advance of the date a change is desired.

E. P. Orcutt, livestock specialist for the Montana State College Extension Service, has resigned to become manager of the Deer Lodge Farms Co., Deer Lodge, Montana.

Louis L. Madsen, nutritionist in the Animal Husbandry Division, Bureau of Animal Industry, Beltsville, Maryland, has accepted an appointment as head of the Animal Husbandry Department, Utah State Agricultural College, Logan, Utah, and will assume his new duties there in the near future.

Banner Bill Morgan, parasitologist and assistant professor of veterinary science at the University of Wisconsin, is the author of a book entitled "Bovine Trichomoniasis," published in 1944 by the Burgess Publishing Co., 426 South Sixth Street, Minneapolis, 15, Minn. It contains 150 pages and is a comprehensive review of both the theoretical and applied aspects of the subject.

J. C. Miller, professor and acting head of the animal husbandry department at Texas A. and M. College, has accepted a position as head of the animal husbandry department at the University of Tennessee, effective February 15, 1945.

Walter Tolman, extension animal husbandman at Washington State College, has resigned to accept private employment with the Inland Empire Pea Growers' Assn., Oakesdale, Wash.

Bruce R. Taylor of the animal husbandry staff, Oklahoma A. & M. College, resigned September 15, 1944, to accept employment as field representative of the American Hereford Breeders' Association at Kansas City, Missouri.

J. F. Wilson of the animal husbandry staff, University of California, visited New Zealand recently for the purpose of selecting some Merino sheep for importation to this country.

J. H. Hilton of the dairy husbandry staff, Purdue University, recently resigned and is now head of the animal husbandry department, North Carolina State College, succeeding A. O. Shaw, resigned to enter private employment.

Mansel F. Grimes, formerly of the animal husbandry staff, Pennsylvania State College, and more recently farm manager for the Alliance Life Insurance Co., became assistant secretary of the American Aberdeen-Angus Breeders' Assn. on January 1, 1944.

Carl F. Sierk, assistant professor of animal husbandry and range management, Montana State College, has been grznted leave to accept a commission in the U. S. Naval Reserve.

George W. Ellis, formerly extension animal husbandman, New Mexico Agricultural College, and more recently assistant manager of Diamond A Ranch properties with headquarters at Roswell, New Mexico, is now assistant manager for the Bell Ranch in the same State.

E. R. Eudaly, formerly swine and dairy extension specialist, Texas A. & M. College, and acting director of Extension Service of the same institution, resigned November 1, to go into commercial work with headquarters at Fort Worth.

A. T. Semple, formerly on the animal husbandry staff of the U. S. Bureau of Animal Industry, returned early in October from more than a year's service with the Foreign Economic Administration in Africa, and will return to Ethiopia and one or two other countries for further work in 1945.

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